E. J. Warwick

UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

ANIMAL HUSBANDRY RESEARCH DIVISION

and

COOPERATING WESTERN STATES

W-1 IMPROVEMENT OF BEEF CATTLE THROUGH THE APPLICATION OF BREEDING METHODS

1965 Annual Report of W-1

and

Report of

Annual Meeting of Technical Committee

Fort Collins, Colorado

September 6 and 7, 1965

This report is intended for the use of administrative leaders and workers and is NOT for general publication

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AGENDA

W-1 Technical Committee Meeting
Colorado State University
Fort Collins, Colorado
September 6 and 7, 1965

W. C. Rollins, Chairman

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	<u>Symposium on Inbreeding and Selection</u>	
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10:45 A.M.	Evaluation of Selection Intensity and Genetic Changes in an Experimental Herd of Hereford Cattle Dr. H. H. Stonaker	
11:15 A.M.	Selection Applied and Response of Traits in Four Inbred Lines of Beef Cattle Dr. Ralph Bogart	
1:00 P.M.	Recent Studies in Beef Cattle Dr. Lewis A. Holland	
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2:45 P.M.	Reports Dr. M. J. Burris, Cooperative State Research Service Dr. E. J. Warwick, Beef Cattle Research Branch Dr. J. S. Brinks, Investigations Leader, W-1	

PERSONNEL

Project Leaders	
Carl B. Roubicek	Arizona
W. C. Rollins	California
H. H. Stonaker	Colorado
Estel Cobb	Hawaii
R. E. Christian	Idaho
A. E. Flower	Montana
C. M. Bailey	Nevada
L. A. Holland	New Mexico
Ralph Bogart	Oregon
J. A. Bennett	Utah
C. C. O'Mary	Washington
G. E. Nelms	Wyoming
O. F. Pahnish	U. S. Range Livestock Experiment Station
Administrative Adviser	
J. H. Meyer	California
Agricultural Research Service	
J. S. Brinks	Investigations Leader
Bradford W. Knapp	Statistician
E. J. Warwick	Chief, Beef Cattle Research Branch
Cooperative State Research Service	
M. J. Burris	Principal Animal Geneticist
Guests Present	
Alan Robertson	Institute of Animal Genetics Edinburgh, Scotland
D. F. Hervey	Colorado State University
Paul S. Pattengale	
T. M. Sutherland	
L. M. Haverland	
T. H. Hall	
Larry Theurer	
Glenn Richardson	
Howard Lindholm	
James I. McNitt	
Peter Fagerlin	
John W. Gowen	
J. L. Lush	Iowa State University
John Gill	Michigan State University
Donald Anderson	Montana State University
Hans K. Hamann	
R. C. Carter	Virginia Polytechnic Institute
Douglas Bennett	Washington State University
Joe Hillers	
Paul O. Stratton	University of Wyoming
Don LeFever	
	Agricultural Research Service
R. S. Temple	Investigations Leader, S-10 Beef Cattle Breeding Research Knoxville, Tennessee
C. S. Shelby	Director Regional Swine Breeding Laboratory Ames, Iowa

W-1 Technical Committee Meeting
Colorado State University
Fort Collins, Colorado
September 6 and 7,1965

W. C. Rollins, Chairman

The conference convened at 8:00 A.M., September 6, at the Student Center.

Dr. D. F. Hervey, Director of Experiment Station at Colorado State University, welcomed the group and pointed out some of the statistics dealing with research budgets, student enrollment, and growth of the University. He emphasized the importance of regional projects and meetings, and expressed his wishes for a successful meeting.

SYMPOSIUM ON INBREEDING AND SELECTION

Chairman W. C. Rollins called on Dr. Stonaker to introduce the first speaker, Dr. Alan Robertson, Institute of Animal Genetics, Edinburgh, Scotland.

Selection Limits

Alan Robertson

Most selection theory in quantitative genetics is concerned with the rates of response of an infinite population to selection. Theories of selection in finite populations have only been developed very recently. They demand the development of some completely different methods of attacking the problem from those usual in quantitative genetics--in particular, we have to go back to the study of changes of gene frequency at individual loci.

The main stimulus for this work comes from some findings of Kimura. He was concerned with selection at a single locus in a finite population and produced some very general formulae for the chances of fixation of particular alleles. Confining ourselves at the moment to genes with an additive action on fitness, Kimura was able to show that, if s was the difference in selective advantage between the two homozygotes, the chance of final fixation of an allele depended only on its initial frequency and the product of population size and selective advantage, Ns.

Further, by examining the equations for the change in gene frequency from generation to generation, it can be shown easily that whereas the pattern of genetic change (which would be described by the distribution of gene frequencies in a population of replicate lines) is determined only by the initial frequency and Ns, the time scale for the change is dependent only on N. It then follows that any computer

analysis of a hypothetical selection process need be run only at one population size. The only condition on this is that s must not be too large. In our experience the practical limits here are more or less a value of unity. We have used this general principle in what might be called the "transition matrix method," which is essentially a way of predicting the change in the gene frequency distribution from generation to generation. If a given number of individuals, N, are chosen as parents each generation, then we may concentrate our attention on one particular population containing 2Nq representatives of a certain kind of allele. Such a population will then generate a set of populations in the next generation which are a binomial distribution with index 2N and mean gene frequency $q + (s/2)\, q(1 - q)$. Specifying this distribution for every value of q, we are then able to follow the change in the gene frequency distribution from generation to generation. We can then easily predict how any property of the population will alter with time. We have made use of this technique in analysing the probable half-life of selection processes and in following the effect of inbreeding and selection when overdominance is present in a population. The half-life of a selection process may be defined as the length of time it takes to achieve one-half of the change in gene frequency which will be achieved at infinite time. It was quite easy to show algebraically that if genes have comparatively small effects so that the effect of the selection process is to take them only, say, one-quarter of their way from the initial gene frequency to fixation at zero or one, then the half-life of a selection process for an additive gene will be 1.4N generations and for a recessive gene it will vary between N and 2N generations. Further, by using the transition matrix method, we were able to show that as the effect of the gene increased (and so the expected change of gene frequency during the whole process increased) so the half-life of the selection process was decreased. Thus, the values given earlier are upper limits. We were able to make use of similar ideas in discussing the effect of some initial generations of selection in the wrong direction on a selection process. Here we discussed what we call the "point of no return." By this is meant the number of generations after which the change in a population produced by selection of a certain intensity in a given population size cannot be entirely recovered by merely reversing the direction of selection. Not surprisingly, for a gene with a small effect, this proved to be 1.4N generations and this again was shown by the transition matrix method to be an upper limit for additive genes. We have done some experimental work, not yet published, on this and find that in our standard outbreeding population of Drosophila, selection in any direction with an intensity of 10/25 for only some six or seven generations makes it very difficult to get back to the starting point on reversing the direction of selection.

We have been able to use similar methods to study the effect of selection in a finite population on a character showing inbreeding depression. the initial population was assumed either to have deleterious recessive genes at low frequency or else genes with over-

dominance for fitness, assumed to be at their equilibrium value in the initial population, i.e., it was not assumed that the two homozygotes were equivalent in fitness. If, then, the selective disadvantage of one homozygote compared to the heterozygote was nine times that of the other, the first allele would have a frequency in the population at equilibrium of 0.1. It was found that the effect of selection in a population in which only deleterious recessives were present depended on the value of Ns, where s is the selective disadvantage of the homozygous recessive. Provided Ns was greater than 2, selection in the end was able to overcome almost completely the effects of inbreeding depression, by removing the harmful recessives from the population. In the early stages of the process the effects of inbreeding were greater than the effects of selection and there were, therefore, minima in the curve of population mean against time (or inbreeding coefficient). These minima seemed to occur at values of F between 0.2 and 0.5. The effect of selection in a finite population on loci showing over-dominance depended very much on the equilibrium gene frequency at these loci. Now we are in a situation in which inbreeding depression cannot be entirely removed by selection because the homozygosity of even the best allele will lead to some loss of fitness, or of the character under selection. When the equilibrium frequency at the over-dominant locus was towards either extreme, then the selection curves are very similar to those of the straight recessive situation. Selection minimizes the effect of inbreeding, not by retaining more heterozygotes in the population than would be expected on the basis of the inbreeding coefficient, but rather by hastening the process of fixation of the superior allele. Only when we move to gene frequencies around 0.5 does selection maintain the population mean by increasing the number of heterozygotes in the population. When the two homozygotes are equivalent (meaning an equilibrium gene frequency of 0.5) then high values of Ns lead to a slight decrease in the character mean in the early generations of selection, followed by very little subsequent change until the inbreeding coefficient becomes very close to unity. It is hoped to publish these results in the near future.

I have so far been talking entirely in terms of the selective advantages of individual genes. What has this to do with selection for a quantitative character? It can easily be shown that there is a linear relationship between the difference between any two genotypes on any measurable character under selection and the resulting selective disadvantage that this selection gives. In general this equation is simply given by $s = ia/\sigma$, where i is the selection intensity, a is the effect of the genetic substitution on the character, and σ is the phenotypic standard deviation of the character. This equation applies strictly to mass selection but similar expressions can be derived for situations of progeny testing and family selection. The chance of fixation of any gene is then dependent on its initial gene frequency and the value of Nia. As the overall advance in the character under selection depends on the changes in gene frequency at the individual loci, each multiplied by their respective effect, it then follows

that the total advance under selection in the quantitative character will be proportional to Ni. Under conditions of individual selection, this expression has interesting consequences. Suppose we rear a fixed total number of animals each generation. N is then the effective number of animals bred from and any attempt to increase the rate of response of selection by increasing the intensity may very well reduce the final limit of selection by reducing N. In fact, it can easily be shown that the maximum advance under selection will be reached when 50 percent of the population are selected each generation. The practical meaning of this optimum,however, depends very much on the actual situation in any population, and it depends on it in a way that is only determinable a posteriori. If in a given population with a given value of i, the value of N is small, then the maximum in the curve of advance against proportion selected may be fairly sharp but as N increases with the same value of i, the curve alters in shape so that there is a long flat region with intermediate values of proportion selected with the curve dipping down at both extremes. The practical problem then is to select as intensely as possible at the moment without too much reducing the advance at the limit.

We have in fact carried out some experiments in which we measured a constant number of individuals and selected at different intensities. Using Drosophila melanogaster we set up a series of subpopulations, in each of which we measured five males and five females in each generation and selected in different sets of lines the most extreme one, two, three, or four files of each sex in each generation. This then exactly parallels the conditions required by the last piece of theory. The lines selected with intensity 1/5, which of course had full-sib mating in each generation, showed tremendous variation between replicates but their average behaviour was reasonably according to plan in that their half-life was between two and three generations. But the total response of the four different sets of replicates was not quite according to expectation and the final order of the different sets was 2, 1, 3, 4. The variation between replicates was so great that we had to carry 25 in each set in order to get a satisfactory answer.

One interesting side light brought up by the theory was that the examination of selection limits experimentally might be a good way of examining the gene frequencies of genes affecting the character in the population. The logic of the method runs roughly as follows: If the selection response is due to the fixation of genes which are at fairly low frequency in the base population, then the formation of subpopulations from one male and one female would reduce very much the advance under selection. It would then be fairly probable that the desirable gene was not present at all in the initial sample of four gametes from which a subpopulation was formed. We carried out such an experiment with our Drosophila population, starting a series of subpopulations each from a single male and a single female followed by several generations of random breeding to allow linkage to re-equilibrate to some extent. Selecting with our usual intensity of

10/25 we found that the "bottlenecking" of the population only reduced the total response under selection by some 30 percent. This was true for selection in both generations. This would certainly suggest that the genes which we fix in our usual selection programs are at intermediate frequencies in the base populations. Nevertheless, we know that our usual limits of selection from our base population are in fact artifacts of the selection method. It is comparatively easy to reach into the population and to get out new genetic material to break through these existing plateaus. I will refer to some of this work later.

Linkage presents a difficult problem in selection theory. In an infinite population, of course, linkage cannot prevent the population from advancing to its usual limits because there is an infinite amount of time for crossing over to occur. The effect of linkage is, therefore, essentially one of finite population size, of having cross-overs of the right kind before the relevant genes go to random fixation. We have been doing some work on this problem both algebraically and using a computer for Monte Carlo studies. An algebraic examination of the equations of selection of linked loci allows an interesting generalization, comparable to that possible with a single locus, where it was shown that the time scale was proportional to N and the pattern of behaviour depended on initial gene frequency and Ns. Switching to two loci, we find that the initial conditions now have to be specified in terms of the frequency of the genes at the two loci and by the linkage disequilibrium between them. It then appears again that the time scale is proportional to N but now the pattern of change is dependent not only on the initial conditions but on Ns_1, Ns_2, and Nc, where s_1 and s_2 are the selective advantages of the alleles at the two loci and c is the cross-over distance between them. This again allows us to do most of our computer runs at a single population size though we are again limited by the values of s that we can use. Linkage then always comes into the solution as the expression Nc but we can go further and say that, partly as a result of theory in a simple situation and of our general results in more complicated situations, the response to selection seems in a great many situations to be a linear expression in $2Nc/(2Nc + 1)$. This we might consider as giving us a "linkage metric." Thus, the value of c which produces an effect on the selection limit one-half that of absolutely tight linkage is given by $2Nc = 1$.

Dr. Hill and I have carried out a series of computer runs based entirely on additive gene action in which we vary the effects of the genes at two linked loci, their respective gene frequencies, and the distance between them. However, because of our discovery of the "linkage metric" we have tended to do runs at very few different cross-over values. Some of the results of this program have been extremely surprising and complicated so that the fact that other more complicated models have not produced very much in the way of generalizable results is not now a surprise to us. The results may most simply be described in terms of the effect of segregation at one locus in preventing changes

of gene frequency at another locus closely linked to it. The results were briefly as follows:

(i) Segregation at one locus did not reduce the chance of fixation at the other until the magnitude of the effect of substitutions at the first locus on the character under selection was more than three-quarters of the effect of the second locus. A further increase of the effect of the first locus might then reduce the change in frequency at the second to less than one-half its value when the segregations were independent. This change then passed through a minimum and then gradually increased again as the effect of the first locus increased.

(ii) The gene frequency at the first locus was very important in this, especially if the gene had such a large effect that it was liable to be fixed in the population even though its initial frequency was very low. Depending on the value of Ns, the curve of change in gene frequency at the second locus when plotted against initial gene frequency at the first drops rapidly to a minimum which may occur at gene frequencies around 0.1, followed by a gradual rise as the initial frequency of the interfering gene increases.

We have been able to discover a reasonable way of looking at these phenomena in terms of the effective population size in which the second gene is being altered in frequency. Suppose the first gene had such a large effect that even one occurrence of it in the initial sample was bound to lead to its fixation. Then in such populations, under tight linkage, the gametes in the final population at fixation are replicates of a very small sample of gametes in the initial generations of selection. The second gene, therefore, has to have its frequency altered in a population which is effectively very small in the early generations of selection. We have been able to extend this theory to provide an algebraical prediction of the effect of the second gene on the first under two conditions:

(i) That under independent segregation the expected change in gene frequency at the second locus does not take the desired allele more than about one-quarter of the way from its initial frequency to unity, and

(ii) That the effect of the second locus on the character under selection is more than twice that of the first.

I should like to finish by describing very briefly some experiments with Drosophila melanogaster on what I think is a fairly important topic. Very frequently we have highly selected lines of farm animals which have run out of genetic variability so that no further progress is possible under selection. Nevertheless, it remains possible that there are present, in lines of inferior average performance, genes which if substituted in the superior lines would produce a further improvement in them. The practical problem is, then: how do we get useful genes out of their bad genetic environment into the good one? This problem turns out to have many constituent variables, assuming that the starting step

will be a cross between the superior and inferior lines. These variables would seem to be:

(i) Should the inferior line be selected before crossing?

(ii) Should selection take place after the first cross, or is it desirable to make further crosses to the superior line?

(iii) Is it desirable to wait after crossing before starting further selection in order to allow linkage combinations to break up?

(iv) Is it possible to select too intensely in this situation so that one merely reconstitutes the genotype of the superior line?

Furthermore, there are two different criteria of success. Presumably the practical breeder wants to produce a line better than what he has at the moment. He is interested in how much extra gain he can get, but also in how quickly he can get it.

We, therefore, started an experiment in which we took a low selected line from our Drosophila population and asked ourselves the question as to how we could possibly get further useful variation into this line from the initial unselected population. In doing so, we attacked variables (i), (iii), and (iv). As might have been expected in an experiment in which we were looking for either rare genes from the initial population or else uncommon cross-overs between common genes, there was a great deal of variation between replicates. Our final conclusions can, therefore, only be stated in very general terms. It seemed that as sufficient crossing-over took place in the early generations of selection after crossing, it was worthwhile selecting immediately and we found some lines going through the previous plateau which had been selected from the F_1 between the superior and inferior line. Nevertheless, our line which went furthest through the previously existing plateau came from a line in which no selection had been practiced for six generations after crossing. Here we have some incompatibility between the wish to break through the plateau quickly and to break through it a long way. Again, there was the same incompatibility in the results of selection before crossing. We tended to go through furthest if we selected for many generations before crossing, but we did this at the expense of waiting for a long time before we went through the plateau at all. Only on one point were our results unequivocal--that the more intense we selected before and after selection the further did we eventually get. But I should emphasize that in such an experiment one cannot be sure that one can get the cross back to the initial level of the superior line. In fact, in the majority of cases the final level reached after selection did not break through the plateau.

The greater part of the results that I have described have not so far been published, but I hope that we will manage to do this in the

near future. For those who would like to delve further into the problems of selection in finite populations, I would suggest that useful references might be found in the following two papers:

Robertson, A. 1960. A theory of limits in artificial selection. Proc. Royal Society B,156:234-249.

Allan, J. S. and Alan Robertson. 1964. The effect of initial reverse selection upon total selection response. Genetical Research 5:68-79.

Evaluation of Selection Intensity and Genetic Changes in an Experimental Herd of Hereford Cattle

H. H. Stonaker
Colorado State University, Fort Collins

Joe B. Armstrong, in his Ph.D. dissertation, has made the first analysis of possible selection effects in 14 inbred lines of Hereford cattle at the San Juan Basin Experiment Station. The study was built upon a previous study of G. O. Harwin's in which the effects of inbreeding, sex, age of dam, and weaning weight were evaluated. Harwin's results were thus used as adjustment factors for the data used in the present study. Estimations of year effect as made by Harwin were not used but rather these year effects were evaluated on the basis of repeat mating analysis in the present study. The study consists of two parts, the first being that of the selection practiced for adjusted weaning weight, weaning score, average daily gain, feed efficiency, final grade, and index. Heritability estimates were computed on the adjusted data by using half-sib analysis, considering the effect of inbreeding on the relationships among these half sibs. This information, with the selection differentials, provided the estimates of anticipated genetic change.

Genetic trends over the period from 1946 through 1962 appear negative for weaning weight, average daily gain, and grade. A slight improvement has been noted in efficiency of feed use. Overall results, however, do not follow the expected results based on the computed heritabilities and selection differentials.

Selection Practiced

Fourteen small inbred lines of Herefords and one control group were involved in the period studied. Selection for performance traits was centered on the bulls. For experimental reasons, the older heifers were saved for breeding without selection for other traits. Unfortunately, all lines including the controls were not included in the experiment over the entire period.

Selection pressure was expressed as the superiority of those animals saved for breeding, relative to the number of animals produced within a line each year. The average amount of selection pressure exerted was based on the percentage of animals saved.

For example, as shown in table 1, bulls saved for sires were in the best 47 percent of all bulls produced for adjusted weaning weight. Heifers saved for dams were in the best 94 percent, indicating that there was practically no culling for adjusted weaning weight of heifers. A percentile of 100 indicates no culling for the trait involved.

As shown in table 1, the average percentage of parents saved for breeding based on adjusted weaning weight was 70. The greatest

selection pressures were for weaning weight, daily gain, and an index based on these two traits. The index used was the sum of the animal's adjusted weaning weight and 50 times the daily gain.

Table 1. Selection Differentials in Percentile Saved in Each Trait per Generation

	Sires	Dams	Average of parents
Adjusted weaning weight	47	94	70
Weaning score	65	87	77
Average daily gain in feedlot	51	100*	75
Feed efficiency	81	100*	90
Final grade	68	100*	84
Index	51	100*	75

*Assumed

With this selection practice there should have been improvement in all traits over the period, considering the heritabilities of the traits. These heritabilities were based on similarities in performance of relatives and are the basis for estimating the degree of change that should result from a given percentile of selection. The heritability estimates are shown in table 2.

Table 2. Heritability Estimates

	Males		Females	
	Inbreds	Noninbreds	Inbreds	Noninbreds
Actual weaning weight	0.49	0.58	0.51	0.60
Adjusted weaning weight	.52	.61	.70	.77
Average daily gain	.56	.65		
Feed efficiency	.88	.91		
Final grade	.08	.12		
Index	.65	.73		

Table 3 shows the expected genetic change per generation of 4.1 years due to the selection of sires, dams, and their average. Based on these expected changes, four generations or 16 years should have increased the average weaning weight by about 50 pounds, the grade by 1/5, and the daily gain by 1/3 of a pound. Obviously, such increases would have considerable economic value if environmental trends were properly evaluated. Actual results fell far short of this.

Table 3. Expected Genetic Change per Generation of 4.1 Years

Due to selection of	Adjusted weaning weight	Weaning score	Daily gain
Sires	21.0	0.06	0.15
Dams	3.7	.04	.02*
Average	12.3	.05	.08

*That due to correlations with adjusted weaning weight

Estimates of Actual and Genetic Change Realized from Selection

Two attempts were made to estimate actual genetic improvement.

Rate of change in the experimental line was plotted against rate of change in the control herd. The small control group had sires selected from the upper one-third of the bulls selling in the local range bull sales at the rate of one new bull each year.

These bulls were selected without knowledge of weights or gains. The rate of change in the control herd was considered an environmental change, although this was probably not entirely the case.

Thus, the inbred lines and control group were compared for relative changes over a period of time. The results show the estimated change in the selected lines to be in a negative direction relative to the controls and quite in contrast to expectations.

Another attempt to estimate environmental shifts in the herd was made by comparing the production of repeat matings in succeeding years. On an average, successive calves produced by the same matings should have the same heredity, and the difference would be used to measure shifts in environment from year to year.

The usual corrections for selection effect as they may influence the repeatability or regression of the successive calf's weight on the first did not appear to be necessary in this study. There was practically no intentional selection among heifers which entered the herd or among cows which stayed in the herd on the basis of their own weaning weight or of their progeny. The lack of selection pressure on the weaning weight of the heifer calves is indicated in table 1. The first heifers born are retained for breeding; the last ones born are fed for rate of gain and carcass information. By proceeding with this plan, there should be freedom from selection bias, not only in the repeat mating data but also in the carcass and feedlot data produced by the surplus heifers.

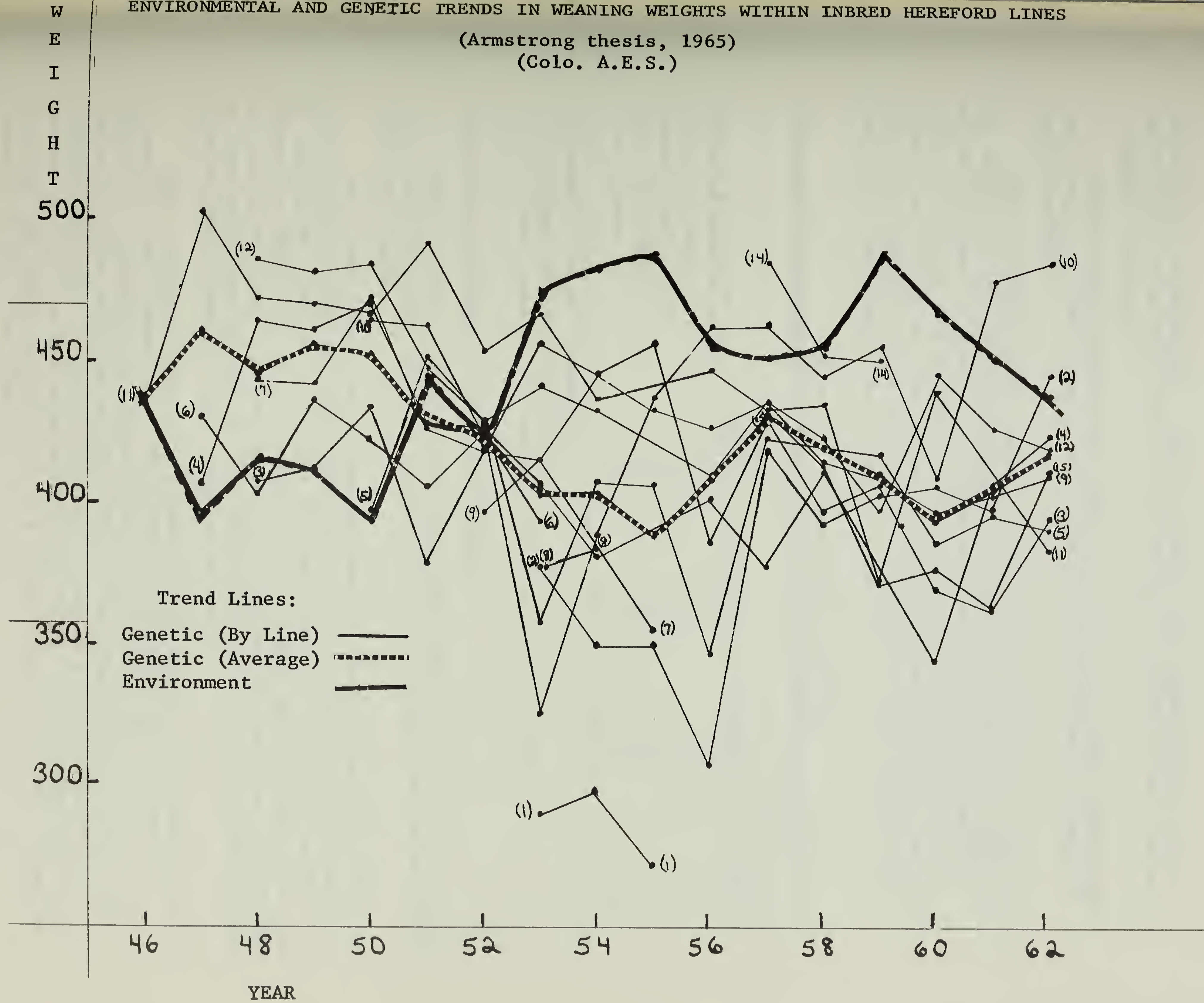
Unfortunately, there were even fewer repeat matings to provide estimates of environmental trends for average daily gain, feed efficiency, final grade, and index. It was assumed that some sort of an estimate of genetic change in these traits might be made relative to the "control" group, realizing the few cattle incorporated in this group. These results are combined with those based on repeat matings in table 4.

Based only on weaning weights, there is evidence of an improving environment for the cattle over the years, as shown in figure 1.

The estimated genetic trend is shown in figure 1, as well. Obviously, there is a negative correlation between the genetic and environmental means. For the 15 years, it was -.9. Theoretically, it should be zero. Large sampling errors on year effect could automatically

ENVIRONMENTAL AND GENETIC TRENDS IN WEANING WEIGHTS WITHIN INBRED HEREFORD LINES

(Armstrong thesis, 1965)
(Colo. A.E.S.)



cause such a correlation. Thus, it seems that repeat mating analysis has not served us very well in this attempt to calculate environmental or genetic trends.

The average environmental change was subtracted from the average total change in the lines to obtain an estimate of genetic change in weaning weight.

The estimated actual changes are indicated in table 4. The results, for selection within lines, appear discouraging. Apparently there was an average genetic loss of an appreciable amount in weaning weight, grade, and gain, and an improvement only in efficiency of feed use. It should be pointed out that these figures are trends--in most cases the level of productivity is higher for the selected lines than for the controls, even though the trends are opposite.

Table 4. Average Change per Year

	Control total*	Lines		
		Total	Genetic	Environ-mental
Adjusted weaning weight	2.4	-3.22	-3.78	0.56[1]
Weaning score	.06	.01	-.05	.06[2]
Average daily gain	.01	-.03	-.04	.01[2]
Feed efficiency	.10	.02	-.08	.10[2]
Final grade	.06	.01	-.05	.06[2]
Index	1.75	-4.46	-6.21	1.75[2]

*Assumed to be environmental
[1]From repeat mating information
[2]Control data used as the measure of environmental change

Production of Lines, Crosses, and Control

While direction and rate of change were the subjects for this analysis, there are other considerations that affect overall evaluation of the breeding program.

The inbred lines and crosses produced by the program vary widely in productivity. Most of these have consistently outproduced the controls. A culling of lines to leave only the best three or four lines would place the production of the herd on a much higher genetic level than that presently existing. Extensive culling of lines has not been done because of the usefulness of some of the lower performing lines in producing good hybrids and because of their research interest.

Thus, reconstructing a herd based on the better lines would raise production considerably over the present herd average as show in table 5. Considering an annual inventory of about 100 inbred cows and comparing this multiline approach to a large single-line approach, for example, the Line 1 herd at Miles City, suggests that a reproducible fast growth rate may be increased more by the small multiline approach than by using the same size cow herd in a single line with greater selection pressure within that line.

In the Miles City herd, an 18-year test indicated the likelihood of an average 22-pound increase in weaning weight and a 54-pound increase in weight at the end of the feeding trial. These improvements are not as great as the differences by which the top three lines in the Colorado experiment exceed the average as shown in table 5.

Table 5. Performance of Best Lines - 1952-62

	Weaning weight	Final weight
	pounds	pounds
Best inbred line	+34	+62
Linecrosses:		
Best crossing line	+39	+81
Best three crossing lines	+24	+56

As pointed out above, the results indicated by this study are somewhat disappointing. Questions arise as to why the downward trend in performance traits. Were environmental trends accurately estimated? Were inbreeding effects underestimated?

However, some of the lines tested were above the herd average and these can be pulled out for producing heavier weaning weights and daily gains. This multiline approach does compare favorably with selection results in a large herd consisting of one line of breeding.

Selection Applied and Response of Traits in
Four Inbred Lines of Beef Cattle

Ralph Bogart
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The study reported herein represents the analysis of the actual selection practiced for performance in four inbred lines of cattle, the response realized from the selection practiced, the levels of inbreeding and associated performance, and heritabilities of the performance traits.

Performance records from 1951 to 1962 were analyzed from three closed lines of Hereford and one closed line of Angus cattle. The three Hereford lines had been closed since 1950. The Angus line was closed since 1950 with the exception of one bull that was used in 1953-55. The management of the calves has been the same for all lines and similar from year to year.

The feeding and management of the calves prior to weaning and the feed-test procedures have been described by Dahmen and Bogart (1952), Nelms et al. (1953), Price et al. (1955), and MacDonald et al. (1956).

Selection of the replacement stock was based on an index composed of suckling gains, gains during the feed test, feed consumption per unit gain, and score for type and conformation. The index for each animal was constructed as follows:

$$I = \frac{S - \bar{S}}{s_S} + \frac{F - \bar{F}}{s_F} - \frac{E - \bar{E}}{s_E} + \frac{G - \bar{G}}{s_G}$$

where S = suckling gain, F = feed test gain, E = feed consumption per unit of gain, G = score, $\bar{S}$, $\bar{F}$, $\bar{E}$, $\bar{G}$ = within-line, within-year, means for respective traits, and s = standard deviation.

The index was constructed on a within-line, within-year basis. One or two bulls were used in each line each year. These were usually bulls which had been performance-tested the previous year. However, some degree of flexibility was retained so that if a bull of outstanding performance were obtained, he could be used for two years instead of one. The Hereford lines consisted of approximately 15 cows in each line, while the Angus line contained approximately 20 cows.

Selection differentials within each of the closed lines were computed by the method presented by Brinks, Clark, and Kieffer (1965) using the performance records of the sires and dams compared to the performance records of their contemporaries. This basically gives a selection differential based on the mean of the selected parents compared to the mean of the entire population from which they were selected. Computations were as follows:

On the sire side

$$\Delta S = \frac{n_1^s s_1 + n_2^s s_2 + \ldots + n_p^s s_p}{N\bar{A}}$$

On the dam side

$$\Delta D = \frac{n_1^d d_1 + n_2^d d_2 + \ldots + n_q^d d_q}{N\bar{A}}$$

For sire and dam combined

$$\Delta P = \frac{\Delta S + \Delta D}{2}$$

where ΔS, ΔD, or ΔP are the selection differentials, n_p^s and n_q^d are the number of progeny by a particilar sire or dam in a given year and s_p and d_q are the superiority or inferiority of a particular sire or dam. N is the number of progeny in a given year, and $\bar{A}$ is the average age of the parents when the offspring are born, or

$$\bar{A} = \frac{\Sigma n_i^s A_i^s + \Sigma n_j^d A_j^d}{2N}$$

$\bar{A}$ is the generation interval and puts the selection differential on a yearly basis when divided into the selection intensity.

Differentials were computed for the following traits: suckling gains, postweaning rate of gain, economy of gain, and score. A selection differential for inbreeding also was computed for each line.

The following numbers of calves were involved in the analysis:

	Lionheart line	Prince line	David line	Angus line
Male calves	59	64	61	78
Female calves	64	66	49	111

Means by line and sex for all performance traits and inbreeding of calf and dam were obtained for the 12-year period. The performance-trait means were plotted graphically to show trends and yearly variations for suckling gain, postweaning rate of gain, and economy of gain. Means were obtained by inbreeding percentage groups of 0, 1-6, 7-12, 13-18, 19-24, and 25 percent and above. The means of suckling gains were likewise computed at these same increments of inbreeding of dam.

Heritability estimates of performance traits in the lines were computed by intra-sire regression of offspring on dam, correcting only

by adjusting female performance to male performance by the difference between the means of the two sexes.

Results

Selection differentials

Selection differentials for each trait considered in the breeding program are shown on a yearly basis in table 1 for each line. The differentials shown are those computed for the sire side and for the dam side of the mating, plus the average of the two. The generation interval and number of animals in each line are indicated. The selection differentials, covering the period of years 1951 through 1962, show that selection has been in a positive direction when both sire and dam are considered for all performance traits.

Except for postweaning rate of gain in the Angus line, the selection differential was larger on the sire side than on the dam side. In order to find the accumulated selection differential over the 12-year period, each figure would be multiplied by 12. As an example, in the Prince line each differential multiplied by 12 shows that selection was for a total increase in preweaning rate of gain of 0.39 lb. per day. Selection was also for a total increase in postweaning rate of gain of 0.38 lb. per day on 65 lb. less feed per 100 lb. of gain. At the same time, selection for a total increase of 1.17 units in score for conformation was applied.

Selection against inbreeding occurred in the Prince and Angus lines, but not in the Lionheart and David lines. In the latter lines, the selection for inbreeding was due to that contributed by the dams. In all cases, the selection differential was negative for inbreeding on the sire side of the matings.

The generation interval, given in table 1, averaged approximately four years, being longest in the Angus line and shortest in the Prince line.

Performance of lines

The performance of lines is shown for males and females by graphs for each of the traits. The data for the Lionheart, Prince, and Angus will be presented because the main points to be considered are present in these data. Suckling gains declined in the two Hereford lines as inbreeding was practiced in spite of positive selection for greater suckling gains (figures 1 and 2). On the other hand, the Angus calves showed a small amount of decline for the first nine years and then a rather marked increase in suckling gains (figure 3).

There was a general pattern for two Hereford lines for feed-test gains in that there was an increase followed by a plateau and then a decline (figures 4 and 5). The Angus calves showed the increase and plateau, but there was no decline in the later years (figure 6).

Table 1. Yearly Selection Differentials for Performance Traits and Inbreeding Computed from the Sires, Dams, and the Parents Combined

	Lionheart			Prince			David			Angus		
	Sire	Dam	P[1]	Sire	Dam	P	Sire	Dam	P	Sire	Dam	P
Suckling gain lb./day	0.0233	0.0111	0.0172	0.0647	0.0001	0.0324	0.0453	0.0052	0.0252	0.0408	0.0012	0.0210
Rate of gain lb./day	0.0194	0.0144	0.0169	0.0617	0.0009	0.0313	0.0480	0.0058	0.0269	-.0388	0.0198	0.0293
Economy of gain lb./100 lb.	-3.46	-2.95	-3.21	-11.02	0.02	-5.42	-12.89	-2.04	-7.46	-12.15	-10.79	-11.47
Score units	0.0598	0.0367	0.0482	0.2019	-.0041	0.0989	0.0562	0.0186	0.0374	0.0662	0.0266	0.0464
Inbreeding percent	-.0003	0.0008	0.0002	-.0054	0.0007	-.0023	-.0009	0.0014	0.0002	-.0031	-.0014	-.0022
Generation interval years		4.17			3.93			4.17			4.24	
Number of animals 1951-62		123			130			110			189	

[1]Both parents

Feed per unit of gain showed a decline followed by an increase in the two Hereford lines (figures 7 and 8). There was a decline in feed per unit of gain in the Angus line in the early years followed by an increase and then a plateau (figure 9).

Conformation showed a marked increase followed by a plateau and then a decline in all three lines (figures 10, 11, and 12).

When the data were analyzed including only the material in 1952-1957 by least squares there had been no decline in rate and efficiency of gains. The model used (Model A) was:

$$Y_{ijkl} = M + S_i + L_j + Y_k + Bx_{jkl} + e_{ijkl}$$

where Y_{ijkl} = the observation on the 1^{th} calf in the k^{th} year, of the j^{th} line and i^{th} sex, with an inbreeding of x_{jkl}, M = the overall effect, S_i = the added effect of the i^{th} sex, L_j = the added effect of the j^{th} line, Y_k = the added effect of the k^{th} year, B = a constant proportional to the linear relationship between the degree of inbreeding and the change in the characteristic under consideration, x_{jkl} = inbreeding coefficient for the jkl^{th} calf, and e_{ijkl} = random error.

Two supplementary models were used: (1) the effect of year was not considered, and (2) the effect of inbreeding was not considered. The models were used omitting first the inbreeding and then the year terms and the differences between these regression sums of squares due first to year and then to inbreeding alone were determined.

In order to estimate any effect of inbreeding of dam on the performance of its offspring, a similar model (Model B) was used in which the effects of: (a) line, (b) sex, (c) amount of inbreeding of calf, and (d) amount of inbreeding of dam were examined. A supplementary model in which the inbreeding of the dam was not considered was used and the difference between the two regression mean squares was considered to estimate the effect of inbreeding of dam which would also incorporate some of the effects of selection pressure. For convenience, the year effect was not considered in this model. An examination of the constants estimated indicates that there is little difference between the results by using the two models.

The analyses showed that there was a significant effect of inbreeding of the calf on its suckling gains. The decline in suckling gains associated with inbreeding of the calf also increased the age of the calf at 500 and at 800 pounds body weight.

Inbreeding of the dam did not significantly influence any of the traits measured except rate of gain which showed a positive relationship with inbreeding during this portion of the study (table 2).

Table 2. Analysis of Variance of Birth Weight, Suckling Gains, Age at 500 and 800 Lb. and Feed Economy

MODEL A

Source of variation	d.f.	Mean Square Birth weight	Suckling gain	Age at 500 lb.	Rate of gain	Feed economy	Age at 800 lb.
Effect of sex, line, year, and inbreeding	10	1796**	1.05**	17407**	4.51**	688860**	48994**
Reduction due to inbreeding of calf	1	62	1.32**	15356**	0.08	695	12040**
Reduction due to year	5	1560**	1.01**	20104**	2.22**	265655**	44697**
Error	269	26	0.06	512	0.05	4089	543

MODEL B

Source of variation	d.f.	Mean Square Birth weight	Suckling gain	Age at 500 lb.	Rate of gain	Feed economy	Age at 800 lb.
Effect of sex, line, inbreeding of dam	6	1994**	1.09**	15617**	6.60**	964396**	52725**
Reduction due to inbreeding of dam	1	7	0.04	3740	1.12**	37191	896
Error	273	54	0.08	863	0.08	10589	1350

**Significant at the 1% level of probability

The relationship of performance traits (suckling and postweaning gains) to inbreeding for the 12-year study are shown in figures 13 and 14 by bar graphs. There was generally a reduction in suckling gains as inbreeding of the calf increased. Postweaning rate of gain showed an increase followed by a plateau and then a decline as inbreeding increased from 0 to 30+ percent.

The lines varied considerably in the performance of calves in suckling gains from dams of different levels of inbreeding. The Lionheart calves showed a curvilinear response in that calves declined and then increased in suckling gains as inbreeding of the dam was increased. The Prince calves showed a progressive decline in suckling gains with increased inbreeding of the dams. There was not a clear-cut association of suckling gains with inbreeding of the dam in the David line. The Angus line showed an increase followed by a decrease in suckling gains as inbreeding of the dams increased.

Heritability estimates for each trait, given in table 3, show a similarity between estimates for rate of gain and economy of gain within each of the lines. Estimates of heritability for suckling gain were all negative and were entered as zero. There was a wide variation in heritability estimates for score among the lines.

Table 3. Heritability Estimated by Intra-sire Regression on Offspring on Dam, Corrected for Sex to Male Basis

	Lionheart	Prince	David	Angus[1]
Suckling gain	0.00	0.00	0.00	0.00
Rate of gain	0.29	0.37	0.42	0.22
Economy of gain	0.21	0.46	0.42	0.24
Score	0.61	0.00	0.31	0.10

[1]Calculated from 1954, after which the line was closed

Discussion

The Lionheart line was established from a cross of the English bull, Atok Lionheart, onto cows of the Earlscourt Ranch in Canada. The bulls used in the foundation of the line were selected from young bulls that were both production and progeny tested. No serious abnormalities have been observed in this line. The Prince line was established from Domino Prince breeding from a narrow base and this line has experienced some expression of both hydrocephalus and dwarfism. The Angus line was established from combining Missouri Barbara and Prince Sunbeam breeding and later introducing a bull of Eileenmere breeding to improve conformation. The cow size of this line has been 20 compared with 15 cows in each of the two Hereford lines.

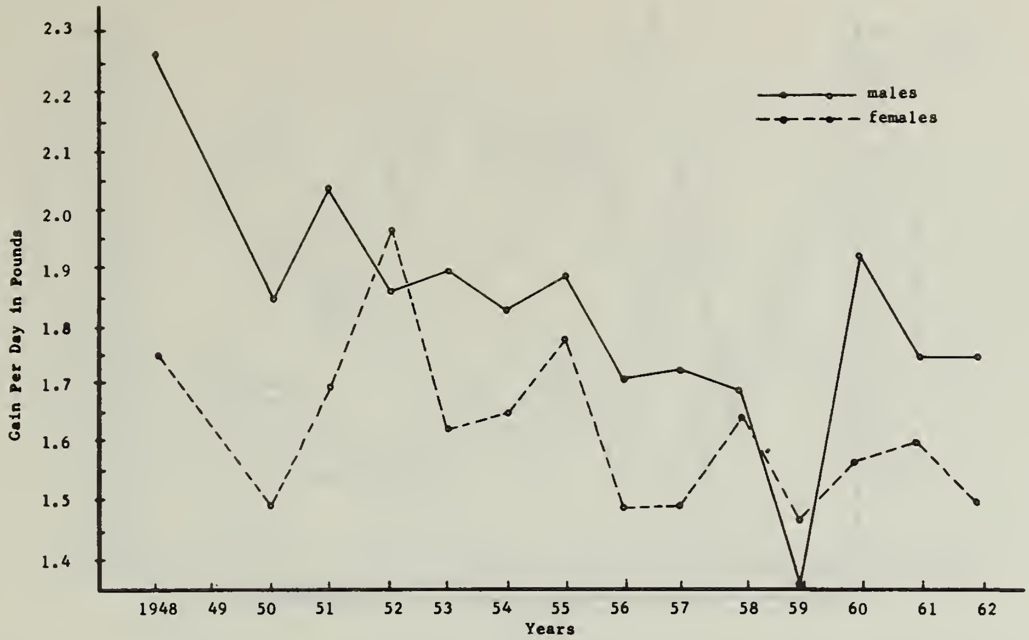

Figure 1. Yearly means by sex of calf for preweaning gain of Lionheart calves

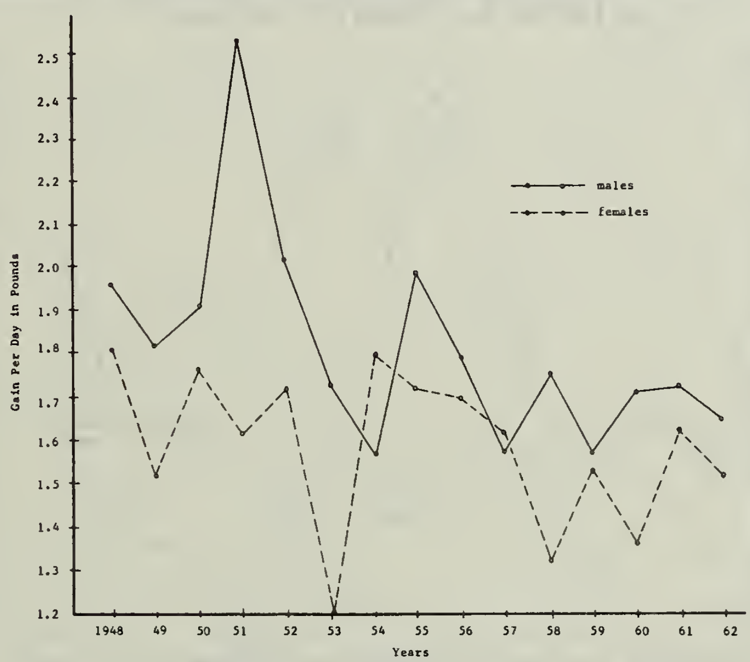

Figure 2. Yearly means by sex of calf for preweaning gain of Prince calves

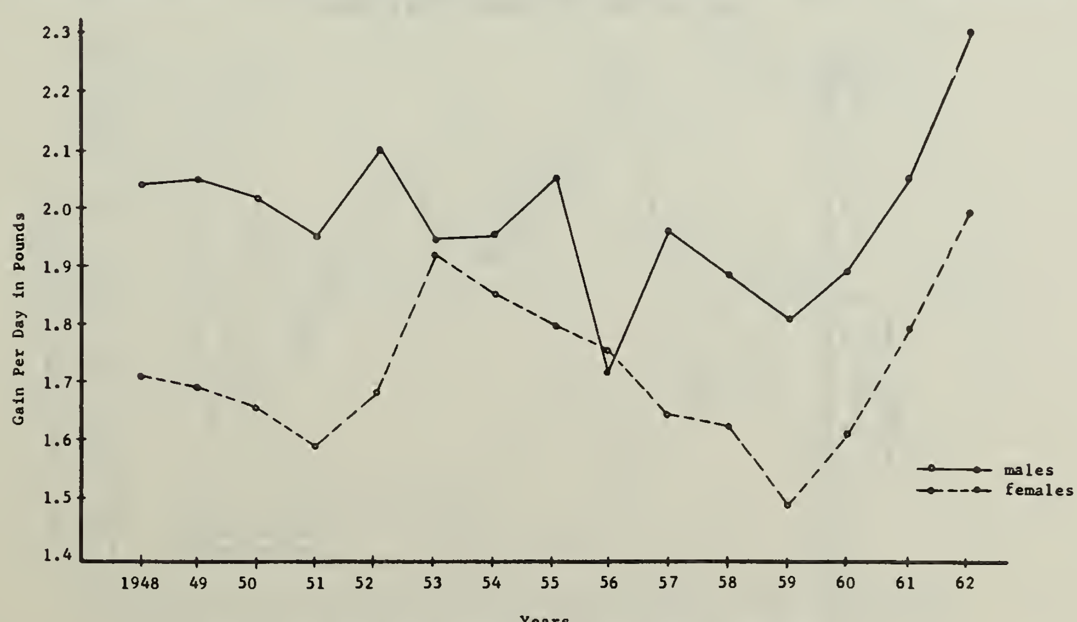

Figure 3. Yearly means by sex of calf for preweaning gain of Angus calves

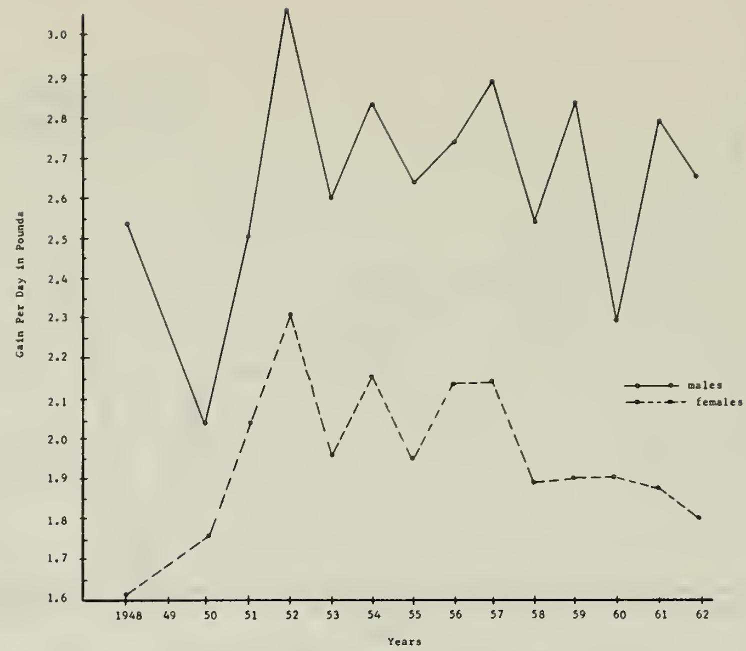

Figure 4. Yearly means by sex of calf for postweaning gain of Lionheart calves

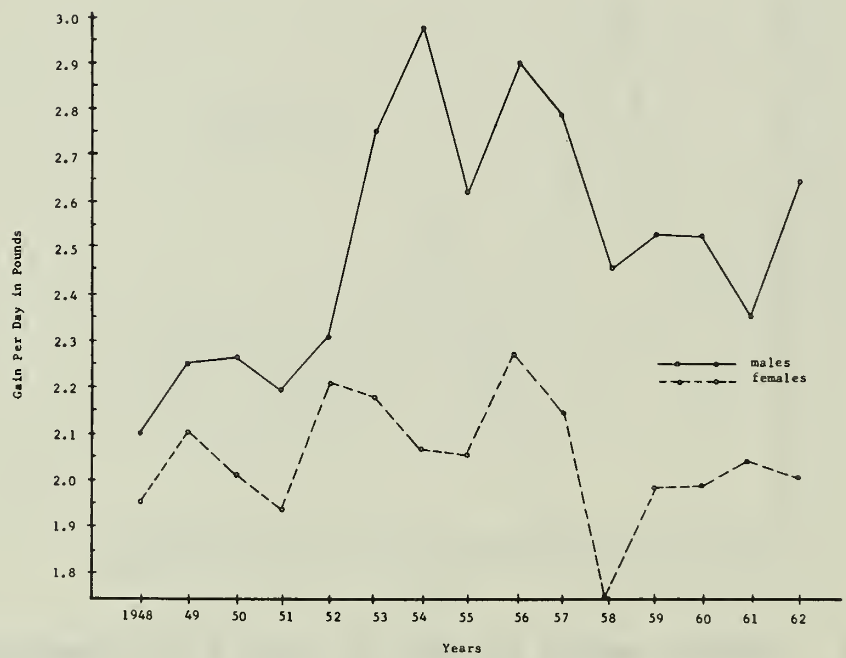

Figure 5. Yearly means by sex of calf for postweaning gain of Prince calves

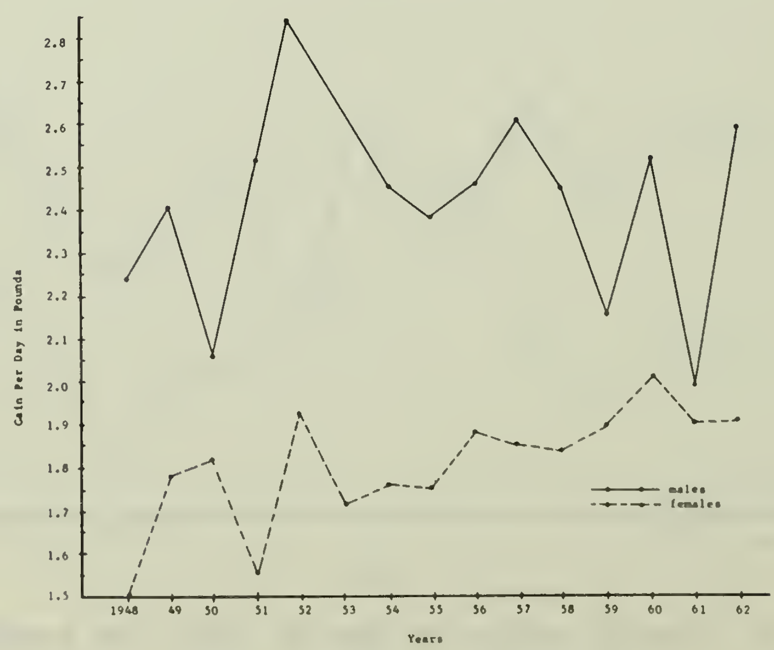

Figure 6. Yearly means by sex of calf for postweaning gain of Angus calves

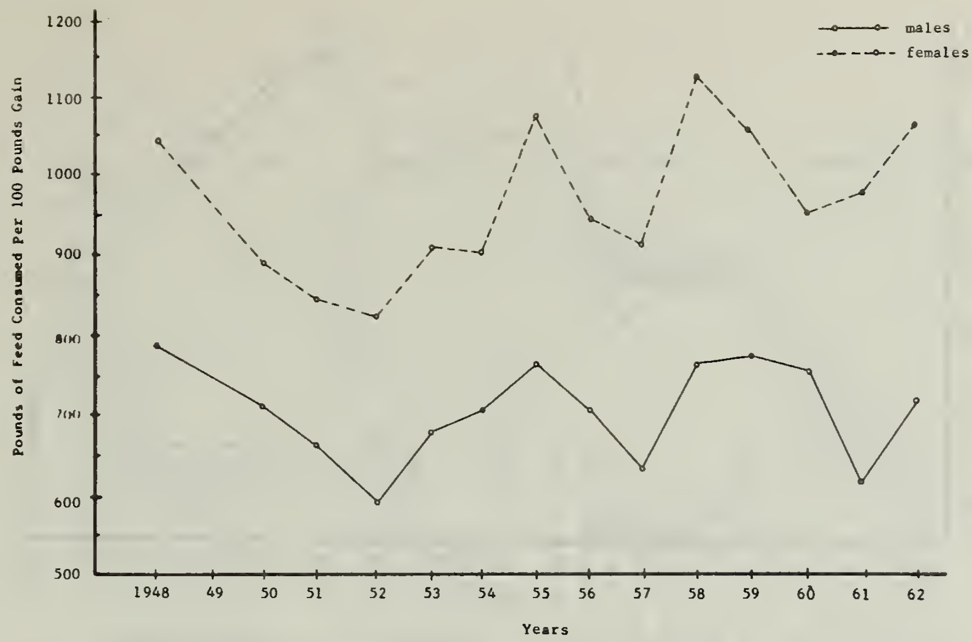

Figure 7. Yearly means by sex of calf for economy of gain of Lionheart calves

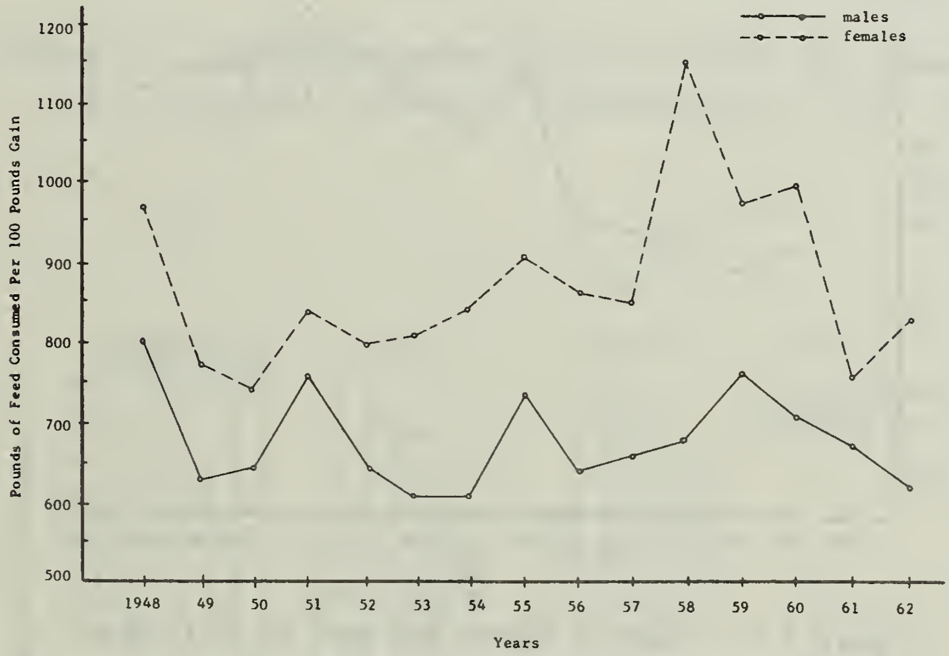

Figure 8. Yearly means by sex of calf for economy of gain of Prince calves

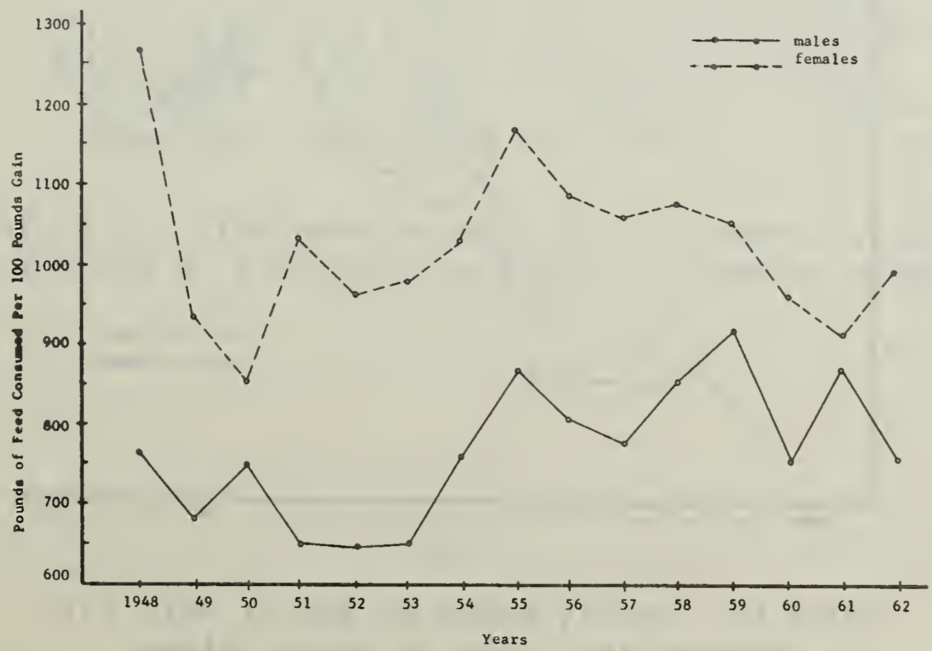

Figure 9. Yearly means by sex of calf for economy of gain of Angus calves

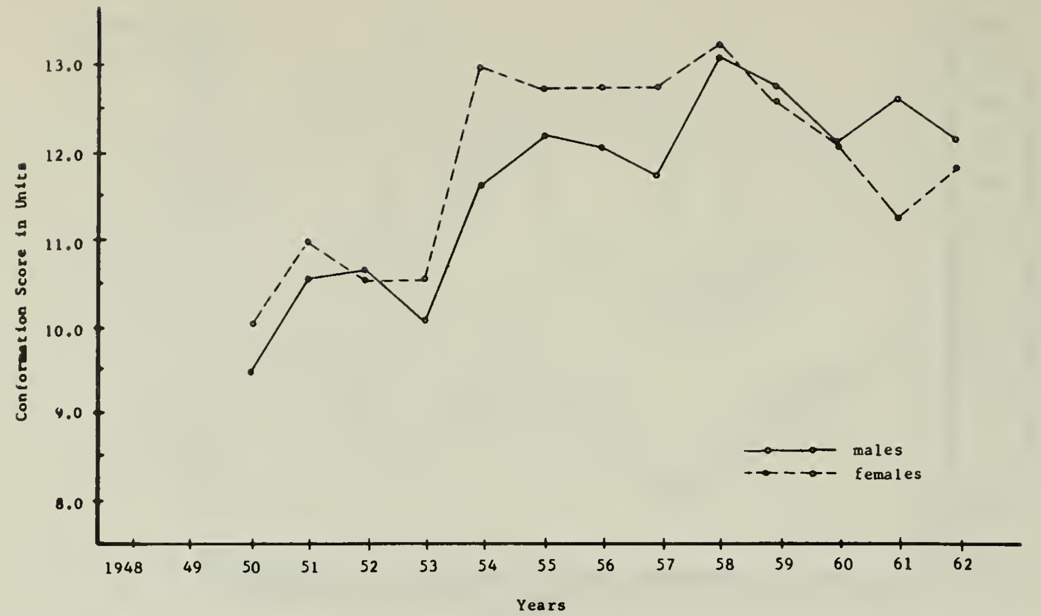

Figure 10. Yearly means by sex of calf for conformation score of Lionheart calves

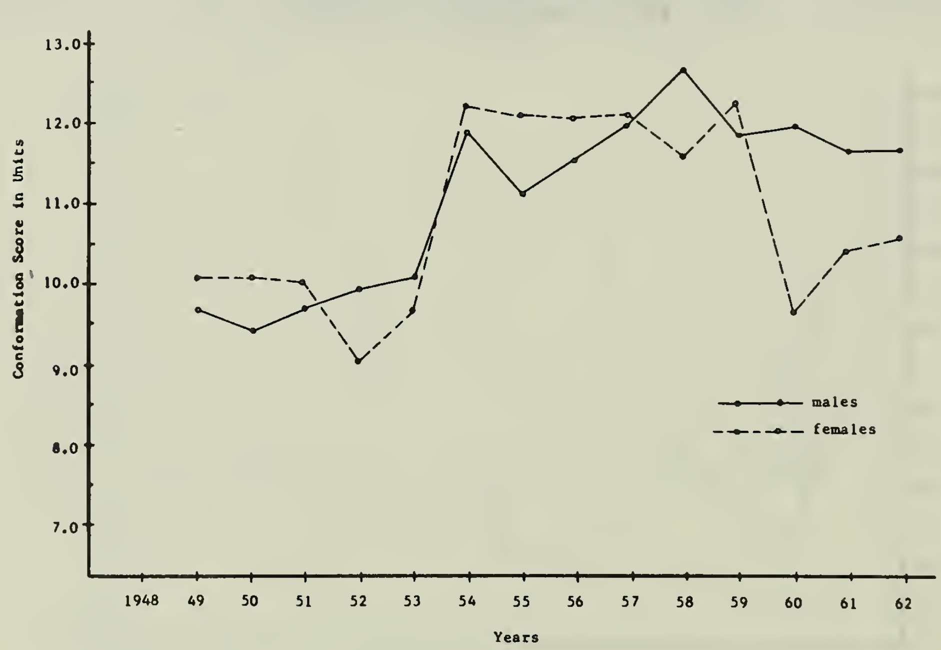

Figure 11. Yearly means by sex of calf for conformation score of Prince calves

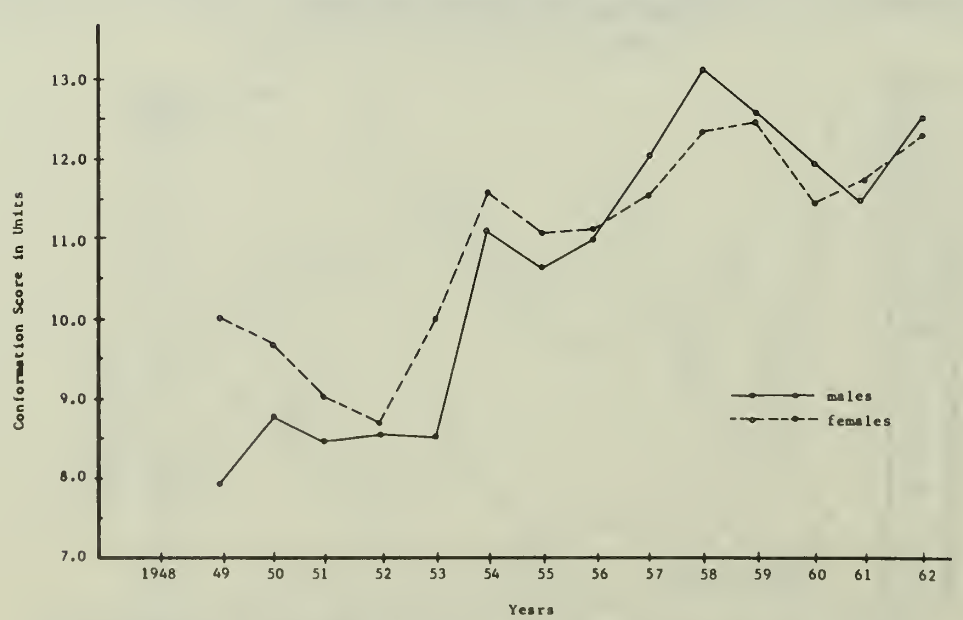

Figure 12. Yearly means by sex of calf for conformation score of Angus calves

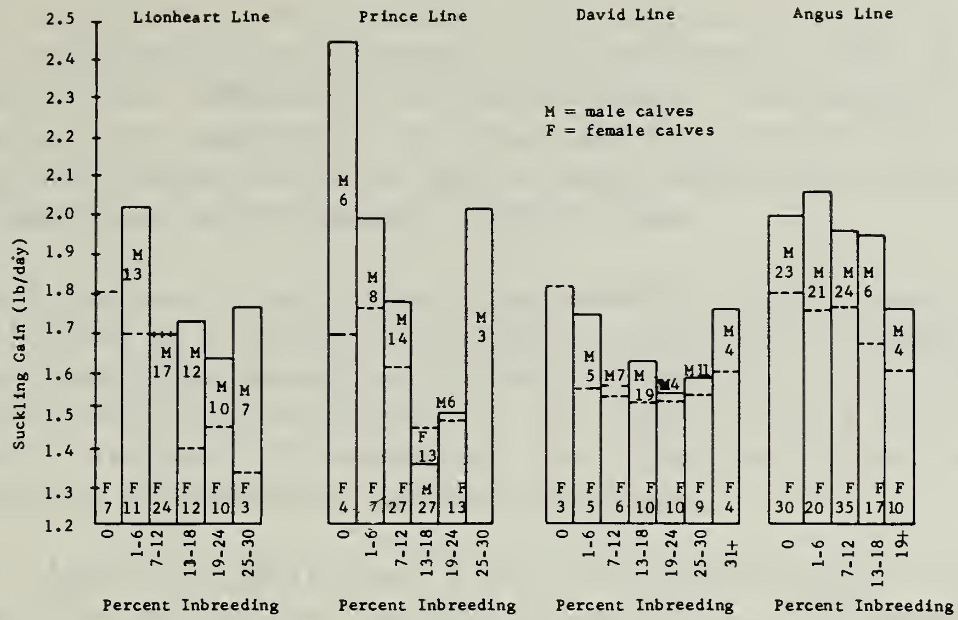

Figure 13. Suckling gain means by sexes and lines at different levels of inbreeding of calf

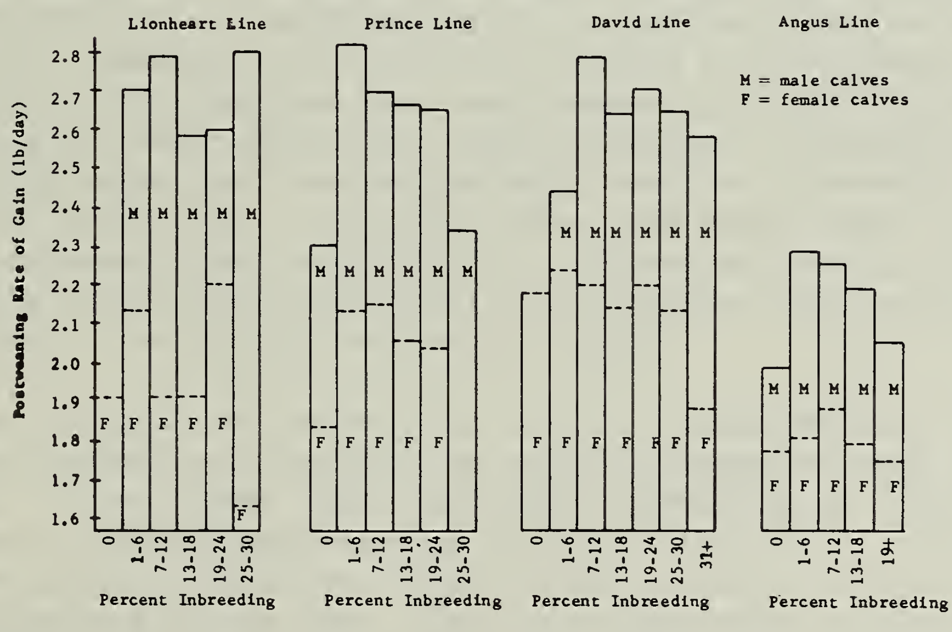

Figure 14. Postweaning rate of gain means by sexes and lines at different levels of inbreeding of calf

It is evident from the data that greater difficulty was experienced in maintaining performance at a desirable level in the Prince line than in the Lionheart and Angus lines. Inbreeding apparently was causing more depression and the abnormal conditions that were cropping out interfered with selection. The results obtained are exactly what one would expect in this line.

The Lionheart line showed considerable improvement in performance followed by a plateau and then a decline. It appears that the wide foundation permitted effective selection but inbreeding influences were soon expressed in this small line first by preventing genetic variability necessary for effective selection and secondly in depressing performance through fixation.

The Angus line, which had a wide foundation and a larger population size, has not shown the depressing effect of inbreeding. In fact, some of the traits are continuing to show improvement.

The use of a selection index in giving equal emphasis to each of four traits appeared to be effective because the selection differentials were approximately equal. As one would expect, the greater portion of the selection pressure was exerted through the sire selections rather than through selection of the dams. The response to selection was not encouraging in small closed populations. The trait of low heritability, suckling gains, showed a negative response to selection. Examination of the data in the earlier phases of the program prior to the decline that was generally exhibited showed that suckling gains were declining with increased inbreeding, whereas postweaning gains and feed efficiency were not showing a depressing effect of inbreeding. It appears that the more highly heritable traits can be prevented from declining in a closed population for a time but that small populations eventually will plateau and decline in performance even in the highly heritable traits.

The influence of inbreeding of dam on performance of her calf has been studied only during the earlier phases of the inbreeding program. It was found that increased inbreeding of the dam was associated with greater postweaning gains of the calf. On the other hand, all other traits showed no relationship in their levels of performance with inbreeding of the dam. This is interpreted to indicate that the more highly inbred dams were also the more highly selected dams which gave an improvement in a highly heritable trait (postweaning rate of gain). The more highly selected dams for the less highly heritable traits did not produce offspring that were superior in these traits. It appears that selection pressure was able only to overcome the inbreeding depression in the dams for the less highly heritable traits.

There was a selection for less inbreeding, particularly in the selection of sires. It would appear from this that there is a selective advantage for the heterozygote. Whether the lack of selection

against inbreeding of the dams occurred because the selection pressure was quite low in females is not known. It is possible, though not likely, that less selection advantage of heterozygosity exists in cows than in bulls.

One observation which tends to refute this possibility is that females showed a greater decline in performance as the inbreeding program progressed than males. This might indicate that there are some genes affecting performance which are in the X chromosome. Inbreeding would tend to create the homozygous state in these sex-linked genes which would result in more marked inbreeding depression in females.

The basis on which the lines were established, the numbers of males and females used in each line, and the genetic merit of the foundation material going into the lines could influence the response of the lines to inbreeding and to selection. In general the Angus line has shown a greater and more continued improvement in all traits than the three Hereford lines. This would be expected because of a wider base and the use of a greater number of males and females in the line. The Lionheart line has performed generally at a higher level than the other two Hereford lines. The Prince line has shown a rather marked decline in performance during the latter part of the study. The decline in performance of the Prince line may be attributable to the difficulties with genetic abnormalities in this line. The general pattern for the performance levels of the traits was a marked improvement at first followed by a plateau after which there was a decline. This pattern was evident if one plotted the performance levels of the traits against time or against levels of inbreeding. One might interpret the results on the basis that selection was highly effective initially because inbreeding actually resulted in greater genetic variability. With continued inbreeding and selection, a certain amount of homozygosity occurred particularly in the genetic material having an additive genetic effect. This would lead to a plateau in level of performance. Finally, in spite of selection, homozygosity developed in genetic material showing overdominance effects and in undesirable genes having epistatic effects which resulted in a general decline in performance level of the traits.

The genetic value of the lines for combining with other material to increase production likely would be great even though there had been some decline in performance levels of traits within the lines. However, there would likely be little opportunity for marked improvement within the lines by selection. The only way to create a high state of genetic variability is to combine the lines for the re-establishment of synthetic lines.

The size of closed lines is probably strongly associated with the length of time that performance can be expected to improve in a selection program, at least for those traits considered in this study.

The optimum number of animals needed for longer term response to selection is not known, but an advantage seems to exist even in the addition of five breeding females to a line of 15, and the use of two sires instead of one, based on performance in the Angus line. A wider genetic base certainly contributed to continued response, however. Any inherited abnormalities will offset advantages gained from increased numbers if individuals periodically are born with defects. On the other hand, if the abnormality can be eliminated by culling an entire segment of the line, performance can be expected to be maintained or improved in the remaining segment of the line if there are adequate numbers.

The size of the lines may also influence the selection, conscious or unconscious, for or against an increase in inbreeding. The small size of lines in the present study led to selection for some degree of heterozygosity, as reflected by selection differentials computed on inbreeding as a trait. This heterozygosity is probably more important early in the calf's life, as indicated by an early decline in preweaning performance in the first years of the selection study. It is also important, however, during the postweaning period as indicated by the decline in performance later in the selection program.

Score for conformation has not shown the same decline with time or with increase in inbreeding as the other performance traits. One can not accept this as evidence that conformation is less influenced by inbreeding than other traits. A trait that is measured subjectively may have been less severely scored as it declined, which would tend to maintain the mean level of the score in equilibrium even though conformation may have actually been declining.

Summary and Conclusions

1. Selection differentials have been calculated for one Angus and three Hereford lines of cattle from 1951 to 1962. Selection was positive for performance on the sire side and usually so on the dam side, resulting in an average positive combined differential. The differentials were higher on the sire side of the matings due to the small number of sires needed; therefore, a greater selection intensity through the sires was made.

2. Selection against inbreeding on the sire side of the matings was automatically done in conjunction with selection for increased performance. Again due to low selection intensity of females, selection was for increased inbreeding on the dam side of the matings, resulting in an average small selection differential for increased inbreeding in two lines and against inbreeding in the other two.

3. Performance since the inception of the lines initially improved after which there was a plateau followed by a decline. This caused the response to selection to be generally negative except for

score in the three Hereford lines from 1951 to 1962. Score responded to selection positively in all lines. Inbreeding increased in all lines. Selection in the Angus line was generally reflected favorably in the response obtained, due to a broader genetic base and more animals from which to select.

4. Zero and low levels of inbreeding were associated with higher preweaning performance and low postweaning performance, with the opposite being true for higher levels of inbreeding. As the highest levels of inbreeding were approached, postweaning performance also declined as more fixation occurred.

5. Heritability estimates differentiated between the highly heritable traits, postweaning rate and economy of gain, and the lowly heritable preweaning gain and moderately heritable score. The proximity between estimates of heritability of rate of gain and economy of gain point out the close association between the two traits at the stage of the life cycle in which they were measured.

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Recent Studies in Beef Cattle

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Recent experiences of analyzing data to estimate effects of inbreeding on birth and weaning traits in the closed lines at the New Mexico Agricultural Experiment Station and study of other analyses cause me to question whether we can accurately measure effects of inbreeding on quantitative traits with existing data and projects. I shall relate these experiences with the hope that those of you who are eternally optimistic can dispell my pessimism.

The numbers of calves by years, lines, and sexes in the New Mexico data are shown in table 1.

Table 1. Number of Calves by Years, Lines, and Sexes (New Mexico)

	Old Line			Outcross Line		
Year	Bull	Steer	Heifer	Bull	Steer	Heifer
1950	1	2	2	6	-	4
1951	3	3	5	5	6	6
1952	5	3	2	7	4	13
1953	8	-	4	6	6	11
1954	2	-	3	3	9	11
1955	7	-	4	6	7	16
1956	8	1	5	6	10	9
1957	7	1	6	5	7	4
1958	5	1	9	3	1	7
1959	13	1	11	2	2	6
1960	8	1	14	1	2	5
1961	10	2	13	3	2	6
1962	8	5	9	-	3	6
1963	5	3	7	1	2	5
Total	90	23	94	54	61	109

Dismayed at the small numbers, I turned to the literature and observed, as summarized in table 2, that others must have had only a shirt-tail of data within lines within years.

Having faithfully taught for several years that the amount of inbreeding depression is dependent upon degree of dominance and <u>gene frequency</u>, I was distressed upon discovering that Alexander and Bogart (1961), Swiger et al. (1961), Stonaker et al. (1963), and Bovard (1964) did not report regressions separately for each line. I grant that data within a year, age-of-dam, sex, and line classification are quite limited. But, of what value are "average" regressions if the

β's in each line are truly different? Bovard (1964) did report regression separately for breeds.

Table 2. Number of Calves, Years, and Lines (Other Stations)

Station	Literature cited	Total number of calves	Years	Number of lines: Hereford	Angus	Shorthorn
Oregon	Alexander & Bogart, 1961	280	7	3	1	
Nebraska	Swiger et al., 1961	283	5	2	1	1
		677	5	10	2	
Colorado	Stonaker et al., 1963	1708	17	14		
Front Royal	Bovard, 1964	2049	14		6	6
Miles City	Brinks et al., 1965	2027	26	1		

My next concern was that ages of the mamas of the New Mexico calves ranged from 2 to 17 years. Alexander and Bogart (1961) apparently did not include age-of-dam in their study. Swiger et al. (1961) tried to handle this source of variation by computing regressions from the pooled sums of squares and crossproducts within year-line-age of dam subclasses. My pessimistic reaction to this procedure is that regressions of birth and weaning traits on inbreeding coefficients may be different among calves out of mature cows from those among calves out of young or aged cows. Stonaker et al. (1963) included age-of-dam classifications in least squares models and reported year × age-of-dam and year × sex-of-calf interactions. Apparently they did not consider the possibility of age-of-dam × inbreeding interaction or, perhaps they did but believed their data were insufficient to test for that. Bovard (1964) did not include age of dam in his analysis. Brinks et al. (1965) adjusted birth and weanling traits to a mature dam basis before computing regressions of traits on inbreeding coefficients.

The studies at Colorado, Front Royal, and Miles City indicate thatt inbreeding effect differs between males and females. The Oregon and Nebraska investigators did not study possible differences associated with sex.

The New Mexico data were analyzed by Moore (1965). Faced with many sources of variation that might affect the traits, and limited data, he chose one of many possible models and analyzed the data. A summary of his results are included in the 1965 annual report to W-1.

Brinks (1965) stated: "In summarizing the inbreeding results in beef cattle, it appears evident that increased inbreeding is associated with decreases in growth and live scores or grades. In general the detrimental effects of inbreeding tend to decrease with increased maturity. However, the magnitude and duration of the inbreeding effect appear to vary widely with breed, line, location, sex, and level

of environment. Inbreeding of dam has a detrimental effect on pre-weaning growth of calves. In many cases this effect is greater than inbreeding of calf. The effect of inbreeding of dam again appears to vary widely with breed, line, location, sex, and level of environment. Perhaps this should be expected."

To this I add that the effects reported will depend upon the statistical model employed by the investigator.

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Selection for Gain, and Correlated Responses in Feed Consumption and Efficiency in Mice

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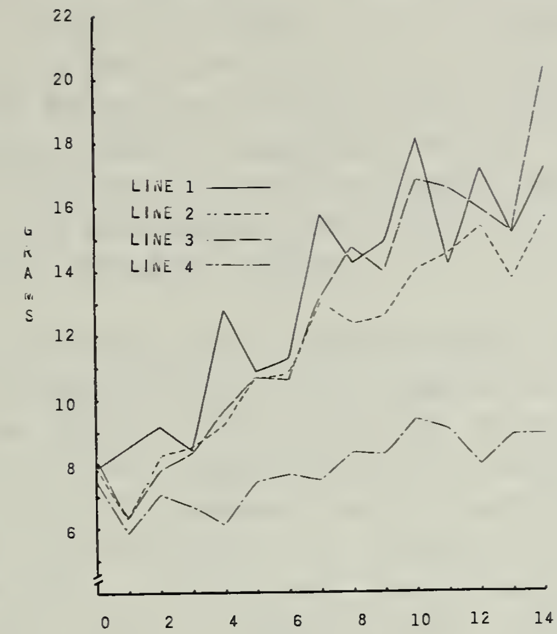
This report covers fifteen generations of selection in mice. For ten generations, three lines each of size 15 matings were selected for gain in body weight between the ages of 4 weeks and 11 weeks. A control line of the same size as the selected lines also was carried, and all litters in all lines were standardized at birth to eight mice. After these initial ten generations, the selection procedure was modified: Line 1 was then selected for efficiency of feed use, Line 2 was selected for feed consumption, and Line 3 continued to be selected for gain, as before.

As is obvious from the first graph, the first ten generations of selection produced very similar results in the three replicated lines. Total gain on test was practically doubled in all lines from an initial value of just under 8 grams in Generation 0 to nearly 14 grams in Generation 9. (The values shown are means of the sex means.) The second graph shows that the feed consumed increased very little in Line 2, and only moderately in Lines 1 and 3, after an initial sharp drop between Generations 1 and 2 due to a change of laboratory facilities. In both gain and feed consumption, meantime, Line 4, the control line, was behaving very much as one would hope a control line should, which was, of course, very reassuring.

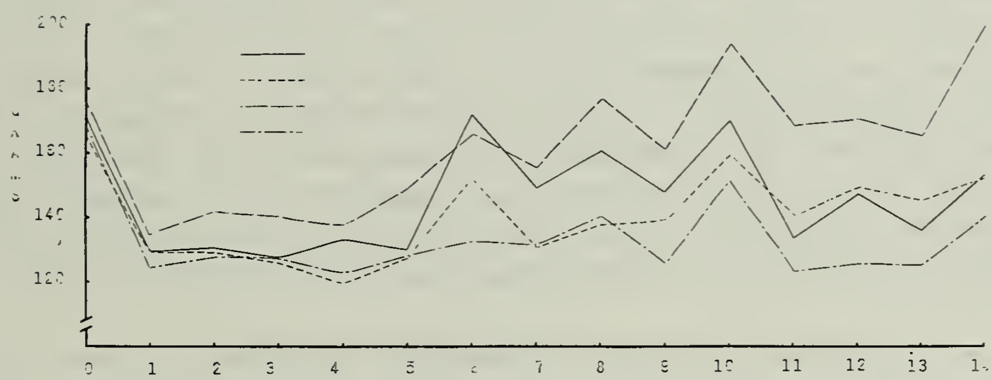
The picture for efficiency of feed use, expressed as grams of feed per gram of gain, is presented in the third graph. Since gain had increased markedly in response to selection, with only very little corresponding increase in feed consumption, the net result was a marked and relatively consistent drop in the grams of feed required per gram of gain, or a marked improvement in the efficiency of feed use. This indicated very strongly a close genetic correlation between feed efficiency and rate of gain. Selection for efficiency, then, should also improve gain. Because the response to selection had been so similar in all three lines, it was decided to investigate this point, and also the effects of selection for appetite. Accordingly, Line 1 was switched to selection for efficiency, Line 2 to selection for appetite, and Line 3 alone was continued on the original selection for gain.

Generations 10 to 14 in the graphs show the results to date. Line 1 (selected for efficiency) has shown an overall improvement in gain, but in exceedingly erratic fashion. Its feed consumption is 4 grams higher in Generation 14 than it was in Generation 9, but has fluctuated over a range of some 36 grams. Its efficiency is still the best of any line at Generation 14, but was so also in Generation 9, so that only the smoothness of response in this character in Line 1 stands out.

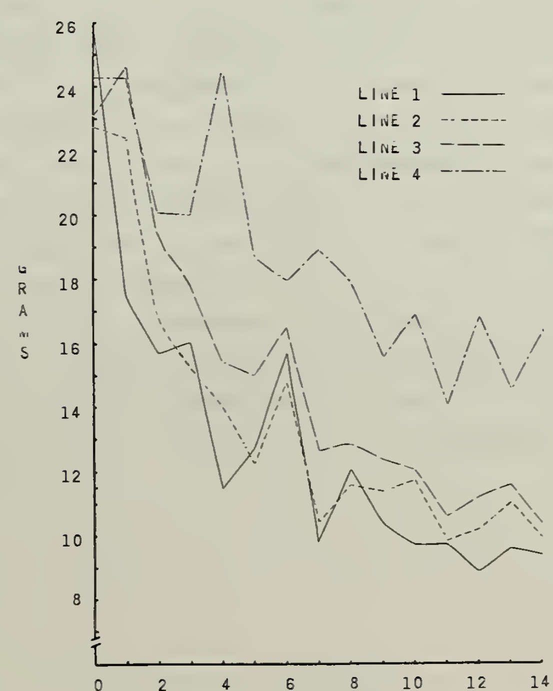
TOTAL GAIN



FEED CONSUMED



FEED EFFICIENCY
(FEED/GAIN)



Line 2, selected for appetite, has continued to show steady improvement in gain, from 12.6 grams to 15.4 grams. Feed consumption has increased by 13 grams, but this is, in fact, small response to five generations of selection directly for the trait. Thus, gain has apparently shown more active response in this line than has feed consumption itself, a rather unexpected result and one which requires further probing. The efficiency of Line 2 has thus improved considerably, although in an erratic manner.

Line 3, selected for gain, has made very great advance in gaining ability in the five generations (20.4 grams in Generation 14 vs. 14.0 grams in Generation 9) but this has come in only two "spurts" (Generation 10 and Generation 14, especially the latter), while in three generations, 11 to 13, "progress" has actually been negative. Line 3 animals also have been the heaviest eaters, consistently so for the last seven generations, and are now consuming considerably more feed than the other three lines. Despite this, however, the efficiency of the line, in response to selection for gain, has continued to improve, the pattern of response since Generation 9 being very similar to that shown by Line 2.

Realized heritabilities for gain in the first ten generations (Generations 0 to 9) have been, respectively, 0.27, 0.30, and 0.24 in the three lines. The average value computed from the sire components of variance is approximately 0.31. The phenotypic correlation between gain and feed consumption averages 0.30 to 0.40, while the phenotypic correlation between gain and efficiency is approximately -.85. The genetic correlations show high sampling variation, but that between gain and efficiency appears also to lie in the area of -.90.

The results indicate reasonably high heritability for rate of gain, with corresponding response to selection. Rate of gain and feed efficiency (measured as grams feed per gram of gain) appear to be very closely related both phenotypically and genetically, and move together in a selection program. Selection for appetite has thus far presented a less clear picture, and further generations of selection are required to clarify the effects of this procedure. Variability in the response to selection pressure from generation to generation makes it hazardous to draw conclusions from segments of the project, even where the segments are fairly large (five generations per segment, for instance), and in spite of the fact that approximately 400 animals were tested each generation, and that laboratory environment was fairly constant. This seems to warn against placing too much faith in results of selection in beef cattle experiments in which few generations have been turned over and in which numbers frequently have been small. Nevertheless, the overall long-run genetic change has been rather striking in this experiment, which appears to leave room for optimism concerning the eventual outcome in efforts to improve beef cattle.

The Inheritance of Longevity in Dairy Cattle

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The disentangling of the interrelationship between milk production and longevity in dairy cattle is of great importance. In this context I mean by the word "longevity" the ability of the cow to survive in commercial herds. Milk yield is, of course, selected for directly by the commercial milk producer and the possibility that there might be an incompatibility between milk production and other elements of survival in the dairy cow is of practical importance. We have to take selection decisions on early measures of yield. Is this likely to get us into trouble in other directions?

It seemed necessary, before starting on any statistical analysis of data on the relationship between early milk yield and commercial longevity, to analyze theoretically the probable consequences on this relationship of the continued selection for milk yield during the cow's life. A mathematical model of the culling process was then set up. This assumes that a series of decisions are taken by the farmer, one at the end of each lactation. The decisions are assumed to be taken on the basis of a "culling variate" of which yield in the previous lactation is a major component but to which other causes of culling will contribute. This variate then exists only in the mind of the farmer. It is his judgment of the overall merit of the cow. If we can assume it to be normally distributed then much of the theory of truncation selection can be be applied. The improvement of milk yield itself is then seen as a correlated response. This theory has relevance in two directions. It acts as a model for the prediction of changes in heritability estimates obtained by half-sib correlations in populations which have been subject to culling on the basis of the individual merit of the animals in the population. These results will be presented in a paper to appear in the next issue of "Animal Production," but the general conclusions were that heritability estimates of milk yield are likely to be slightly reduced (not more than 10 percent) by culling of the kind usually practiced.

The theory led, rather surprisingly, into an analysis of the selection process itself and in particular into a discussion of the conditions under which the usual equations for the prediction of genetic change in a population in any characteristic, by a multiplication of the selection differential by the heritability, is justified. It appears that, if the selection is actually carried out by the farmer on the basis of a rather uncertain combination of traits that he can observe on the cow, it is only a matter of great good luck that the equation will apply. But the theory also provided a solution to this problem. If it can be assumed that there are no non-genetic differences in the character between progeny groups and that the selection has been applied solely on the basis of individual performance,

then the genetic effect of the selection process on any characteristic whatsoever can be estimated from the relationship between the proportion of a progeny group surviving the process and its mean for the character concerned. If selection had been directly applied to a character then it would be expected that the regression of the proportion of a progeny group surviving the selection process on their mean for the character under selection would be equal to the phenotypic selection differential divided by the total variance of the character. A comparison of these two then gives some indication of the probable effect of a selection process on a given characteristic even though we have little idea of the criterion on which the selection was based.

The theory was extended to consider in particular the probable relationship between early measures of milk yield and survival of cows to later ages. If selection is being applied continuously throughout the cow's life, if the genetic correlation between milk yield at different ages is reasonably high, and if there is no incompatibility between milk yield and other causes of culling, then it appears probable that the regression of relative survival of progeny groups on their heifer milk yield will increase linearly with the number of culling processes survived. By "relative survival" here, we mean the survival of a progeny group divided by the average proportion of the whole population surviving to that age. It is to be expected that bulls with a high heifer progeny test for yield will have a higher porportion of their daughters having a second lactation, but the critical question is whether two bulls differing in heifer progeny test for milk yield will differ in the proportion of their daughters able to survive the culling which will take place at the end of, say, the fifth lactation.

We have managed to get together quite a lot of evidence on the relationship of early milk yield to survival, both at the level of individual animals and of progeny groups. That on individual animals is shortly to be published. I will only mention two points here. The first is that the relationship of survival to have a second lactation with first lactation milk yield is almost exactly of the form which derives from the mathematical model of culling. The second point is the relationship of culling to the average level of milk yield in the herd. We found that the proportion of animals surviving to a given age was higher in the high producing herds and that this was apparently not because of culling of cows for other reasons in the low producing herds but because in this latter group the attention paid to milk yield in selection was greater than in the higher producing group. As a result, the selection differential for milk yield was almost twice as great in the bottom third of herds as it was in the top third. When actual survival curves were drawn out it was found much to our surprise that if survival was plotted against absolute yield the curves for all herd groups were almost identical. This would suggest that, in Great Britain at least, farmers do not select their cattle in relation to the average production of the herd but in relation to some absolute

standard. Thus, a cow giving 9,000 pounds as a heifer has precisely the same chance of survival if she is in an 8,000, 9,000, or 10,000 pound average herd.

We had three samples from which we could analyze the relationship between the survival of progeny groups to different ages and their average heifer milk yield. The regression of the relative survival coefficient to any age on the average milk yield of the progeny group increased continually as age increased. Thus, if we take bulls differing in heifer progeny test by 1,000 pounds the bull with the higher test will have, on the average, 10 percent more daughters surviving to have a second lactation, 20 percent more having a third, and 50 percent more having a sixth. We found no evidence whatsoever that there was any incompabibility between early milk yield and resistance to diseases later in life. We were able to predict that for every 1,000 pounds difference between two progeny groups in heifer milk yield, there would be an increase in average length of dairy life of 1.2 lactations and of more than 10,000 pounds of milk produced in the lifetime for each heifer calved. These results would indicate that selection can be satisfactorily based on early production.

I feel that it is probable that these results could be applied equally well to a study of the characteristics of a beef cow which were associated with length of life and to a study of the probable genetic changes produced by such selection.

The topics here discussed are dealt with at greater length in a series of papers by myself, Dr. Barker, and Dr. Hinks, which will appear soon in "Animal Production."

Breeding Methods for Beef Cattle in the Southern Region

A Summary of the S-10 Southern Regional Beef Cattle Breeding Project and Recent Results

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The original project outline has been followed since the S-10 Southern Regional Beef Cattle Breeding Project was initiated in 1948. However, a revision is underway at the present time. Although results of studies under the original project have been significant, a revision was deemed necessary in order to incorporate new techniques and ideas and to reorient emphasis as currently indicated.

Since the original S-10 project was written, additional states have contributed, permitting more intensified research on beef cattle breeding. The twelve states presently contributing are: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia. The three contributing federal experiment stations are located at Brooksville, Florida; Jeanerette, Louisiana; and Front Royal, Virginia.

Briefly, the objectives of the revised project and the procedures to be used for attaining these objectives are as follows:

Objective 1. To evaluate systematic breeding procedures

Inbred lines and selected strains of beef cattle will be developed to evaluate their potential for crossing as individual strains per se. Crosses among breeds of both similar and dissimilar geographic origin will be made, using various crossbreeding schemes, to evaluate heterotic effects--including general and specific combining ability--and to compare breeding systems.

Objective 2. To estimate genetic parameters and genetic-environmental interactions of biological and economic traits

Appropriate data from contributing stations will be analyzed to estimate genetic parameters such as heritability, genetic correlations, repeatability, and selection differentials of economic traits. Data from experiments designed to study genetic-environmental interactions will be analyzed to determine the importance and extent of such interactions.

Objective 3. To develop and evaluate selection criteria and selection procedures

Criteria and procedures for selection of economically important traits will be evaluated from a theoretical standpoint and in view of results of selection experiments in the region. Objective criteria

will be developed and evaluated according to their effectiveness in reflecting genetic variability among breeds, lines, sires, and individuals for economically important traits. Evaluation techniques will be studied in cooperation with meat technologists, nutritionists, physiologists, and so forth, as appropriate.

Objective 4. To estimate the progress expected from the use of these selection criteria and procedures

Research will be conducted to estimate genetic and phenotypic changes by selection for single traits and correlated responses in other traits. Selection methods such as mass selection, family selection, and recurrent selection will be studied to determine the progress expected per generation. Genetic control populations and repeat mating schemes will be used to aid in estimating progress by selection.

Objective 5. To determine hereditary significance of recurring abnormalities

Studies of the inheritance of quantitative traits will be conducted when and where possible. Estimates of the economic importance of such traits will be made and methods of identifying each genotype will be investigated.

I. Procedures

At Alabama, purebred Angus and Hereford cow herds of about 120 each will be used in a genetic-environmental interaction study. Two herds in each breed are assigned to two different nutritional regimes. Purebred and crossbred females produced in the initial phase of the Alabama crossbreeding study will be used to measure heterosis in the dam in a second phase of the crossbreeding work.

At the Arkansas station, purebred Angus and Hereford cow herds of about 200 each are being used to study procedures to identify carcass desirability and lifetime productive efficiency at early ages in beef sires and dams. Characteristics that may be related to, and indicative of, subsequent reproduction, mothering ability, and longevity, are being studied to explore the relationship of preweaning and postweaning development patterns, puberal phenomenon, and behavior patterns to produce traits expressed later in the life of the cow. Lifetime patterns of development and production are being recorded and studied through the use of weights, body measurements, and annual type classifications. These records are consistent with records taken in these herds since 1940, and will provide reference points for evaluation of population changes.

At the University of Florida, the value of crossbreeding with Brahman, British, and crossbred foundation cattle is being studied in various crossbreeding systems using different breed combinations. Straightbred Angus, Brahman, and Charolais will be compared with the

reciprocal first crosses in all possible combinations. At the Range Cattle Station at Ona, Florida, the second phase of this study will utilize the straightbred and crossbred females mated to bulls of three breeds. Workers at the Everglade Station at Belle Glade are conducting a crisscrossing program involving all combinations of straightbred Angus, Brahman, and Hereford; and Angus and Brangus cattle are being used in a straight-breeding and crisscrossing comparison. At the Beef Research Unit at Gainesville, upgraded Angus and Hereford groups will be compared with crisscrosses of Angus × Hereford, British × Brahman, and British × Santa Gertrudis. At the Quincy station, different methods of selecting and culling females are being compared, using two groups of 50 cows each. Group 1 heifers will be selected on the basis of their own record, and cows will be culled only for reproductive failure, extremely substandard production, and age. In Group 2, all heifers (with exception of obvious culls) will be bred, and cows of producing age will be culled on the basis of expected lifetime ability to keep numbers constant. At the Indian Reservation, three herds of approximately 300 cows each will be selected for different traits to determine adaptation of cattle with different characteristics to the Gulf Coast conditions. Herd 1 will be selected for large skeletal size only, Herd 2 will be selected for condition score, and Herd 3 will be selected on an index including weight and grade. Dwarf research also is being continued at the Florida station.

At the USDA station at Brooksville, Florida, purebred Angus and F_1 Brahman-Angus females are being used to progeny test sires to measure the magnitude of, and the genetic relationships involved in, specific combining ability. Genetic-environmental interactions are being studied in a cooperative project between the Brooksville station and the station at Miles City, Montana. The Brahman and Santa Gertrudis herds at the Brooksville station are being used to study the reproductive ability of these breeds.

At Reidsville, Georgia, the value of grading up, crisscrossing, and rotational crossing as breeding systems for commercial beef production is being studied. Angus, Polled Hereford, and Santa Gertrudis; the three possible crisscrosses; and one rotational cross will be maintained through three generations to evaluate these breeding plans.

At the same location, selection for single items of importance--weaning weight, rate of postweaning gain, type, and an average control--is underway to determine the relative effectiveness of selecting for single characters and to observe correlated response in nonselected traits. At Tifton, Georgia, approximately 100 Polled Hereford and 50 Angus females are being used to evaluate selection criteria based primarily on preweaning and postweaning growth rate, carcass meatiness, and tenderness.

The Kentucky project has recently been revised to study selection for carcass traits.

At Louisiana State University, six breeds of sire--Angus, Brahman, Brangus, Charolais, Hereford, and Shorthorn--have been used on cows of four purebred breeds--Angus, Brahman, Brangus, and Hereford--and 20 kinds of crossbred dams to compare purebred, single-cross, backcross, and three-breed cross calves each year. The crossbred dams consist of all possible single crosses between the six breeds of sire and four breeds of dam. Charolais and Shorthorn sires are involved in only three of the mating systems since no purebred Charolais or Shorthorn cows are in the project.

The USDA Iberia Livestock Experiment Station at Jeanerette, Louisiana, is utilizing approximately 120 cows of each of two breeds--Angus and Brahman-Angus--in a selection study. A random half of the cows of each breed constitute a herd to be selected for high fat, while the other group is selected for low fat (low lean and high lean) utilizing ultrasonic evaluation of fat thickness on live animals. At the same station, approximately 100 Angus cows will be used in a long-term study of selection for improved performance of a British beef breed under Gulf Coast conditions. Approximately 70 cows have been designated as a "local" herd and are bred only to bulls from within the herd or from outside the herd but from the immediate Gulf Coast area, while the remaining cows are bred to the best bulls available from outside the Gulf Coast area.

At the Mississippi station approximately 250 grade cows of Hereford, Angus, and Shorthorn breeding are being used to progeny test inbred and linebred bulls from throughout the Southern Region as well as from experiment stations outside the Region. Bulls from the inbred and selection lines at the Front Royal station will be tested at the Mississippi station under this plan.

At the North Carolina Station, approximately 225 breeding-age Hereford females are being used at four locations in a study of genetic-environmental interactions. A purebred herd located at Raleigh is the source of most bulls to be progeny tested at the other three locations.

At the South Carolina station the magnitude and importance of environmental influences on genotype are being evaluated. Angus and Polled Hereford cattle are being maintained at two locations which represent the extremes of environmental conditions within the state.

At the Tennessee station, Angus cows at the Plateau Experiment Station at Crossville and at the Ames Plantation in West Tennessee have been divided into three herds--a within-herd sire selected line, an outcross or outside-selection line, and a control line. Four Hereford bulls performance tested on a high level of concentrate feeding and four tested on a high level of roughage feeding will be randomly mated each year to a uniform group of approximately 200 Hereford cows at the Oak Ridge, Tennessee station.

Work at the Texas station has centered around the development of breeding systems designed to evaluate specific and general combining ability and systems of exploiting hybrid vigor. Exotic and untested breeds and strains are objectively evaluated to determine genetic variability and productive level, per se, and for heterotic utilization. Differences in lactating responses in beef cows will be related to nutritional requirements of calves, their growth responses, and correlated productive traits in the cow, as well as to productive and carcass traits in the calves. Differences in metabolic or utilization efficiency of feed associated with differences in genotype will be estimated.

Recently the Texas station in cooperation with the Agricultural Research Service initiated a basic beef cattle genetics study. Immunogenetic and related properties will be associated with productivity, incompatability of genotypes, and other properties. The cytogenetics of beef cattle including karyotyping transferrins and hemoglobin types will be studied.

The Virginia Agricultural Experiment Station has as one of its main contributions to the S-10 project the study of reproductive performance of straightbred and crossbred dams and the performance of their crossbred progeny in order to measure heterosis and maternal effects without confounding these with heterosis in the calf. The crossbred cows will be bred to straightbred bulls and the straightbred cows will be bred to crossbred bulls to produce three-breed and backcross progeny. This work is being carried on at Steeles Tavern, Virginia. At the main station at Blacksburg, a Shorthorn herd has been assembled in order to test the inbred and selection lines that have been developed at Front Royal. Data collected through the Virginia Beef Cattle Improvement Association are being used to estimate genetic and nongenetic parameters and to develop and evaluate selection criteria for beef cattle under farm conditions.

The work at the Beef Cattle Research Station at Front Royal, Virginia involves the development of inbred and selection lines and the subsequent crossing of these lines. Three breeds--Angus, Hereford, and Shorthorn--are being used. Four inbred lines and two selection lines were established from 32 daughters each of four foundation sires that were performance and progeny tested. In one selection line replacements are chosen on growth rate alone, with equal emphasis given to preweaning and postweaning growth rates. In the other selection line, replacements are chosen according to conformation score only. A third selection line has been established in the Hereford breed in which replacements are chosen on an index giving equal emphasis to growth rate and conformation score.

II. Results

Approximately 11,265 beef cattle were inventoried on the S-10 project as of July 1, 1965. This total inventory includes approximately 5,545 cows two years old or older. Approximately 856 bulls,

some of which belonged to cooperators, were performance tested during the past year. Carcass information was collected on approximately 154 bulls, 242 heifers, and 907 steers.

Much of the research in the Southern Region is of a long-time nature and is now yielding considerable worthwhile information. In crossbreeding, for example, 12 years of research have been completed at Louisiana State University comparing single crosses to straightbreds and five years of detailed comparisons of straightbreds, single crosses, backcrosses, and three-breed crosses have been concluded. Over ten years of crossbreeding work has been carried on at the Virginia, Florida, Georgia, and Alabama stations. Crossbreeding work was in force at the Texas station when the S-10 project was initiated. The inbreeding and selection work at the Front Royal station is in its fourteenth year, and projects investigating other aspects of beef cattle breeding were initiated at Alabama, Arkansas, Florida, Georgia, Tennessee, Texas, Virginia, and Jeanerette within a few years after the approval of the S-10 project in 1948. Other contributing research in some of the above-mentioned states, as well as in Kentucky, Mississippi, North Carolina, and South Carolina, has been initiated more recently but already is yielding significant results.

Briefly, some of the more recent and interesting results are as follows:

1. Performance traits

Considerable evidence continues to indicate that preweaning growth rate and type score are approximately 30 percent heritable. A summary of data collected over an eight-year period at the Virginia station indicated heritability estimates of between 0.30 and 0.38 for average daily gain and 0.33 and 0.36 for weaning grade. Phenotypic and genetic correlations between preweaning average daily gain and weaning grade were both 0.23 for Angus and 0.28 and 0.21, respectively, for Hereford calves. At the Arkansas station, however, slightly lower heritability estimates for preweaning growth rate were obtained. These estimates, based on regression of offspring on sire and involving 20 sire groups and 210 male progeny, were 0.19 for 120-day weight, 0.27 for initial test weight, 0.93 for test daily gain, 0.43 for feed consumption, 0.14 for feed conversion, 0.15 for type score, 0.37 for final test weight, and 0.79 for production index.

Summarization of records from several stations indicated that wide environmental differences exist between states and even stations within state for many of the economically important traits. Due to these differences, it may be erroneous to apply one set of adjustment factors for certain effects over a wide geographic area or draw conclusions from one state's work or one experiment and apply these results in other areas.

One recently completed study at the Jeanerette station on Brangus and Africander-Angus indicates the fairly high correlation of growth in different periods. Correlations of over 0.8 were obtained between preweaning average daily gain and weaning weight, 0.37 to 0.59 between preweaning average daily gain and 18-month weight, and 0.31 to 0.57 between preweaning average daily gain and 24-month weight. The relationship of weaning weight to 18-month weight was 0.76 to 0.88, and the correlation between weaning weight and 24-month weight varied from 0.62 to 0.78.

In work relating to feed consumption and other economic traits, the Arkansas station reports that about 59 percent of the variation in gain is associated with feed consumption and initial weight. In this same study, bulls with heavier testicles were poorer converters of feed when put on a constant weight basis; whereas the bulls with more lean tissue, as indicated by cut weights and muscle area, were better converters of feed. This might suggest that as the bull matures sexually and the endocrine function of the testicles increases it elicits two effects on feed conversion that are antagonistic. In the same study, agonistic behavior and social rank within the pen were correlated with eight production traits and eight body measurements of performance tested bulls. No breed differences in agonistic behavior were noted. Chest depth and heart girth were significantly correlated with agonistic behavior within a group, but pooled correlations were low for chest depth and heart girth.

Several S-10 studies on the relationship of cow size to productivity indicate that cow size is heritable and may be related to production. Analysis of data from the North Carolina station indicated that cows which were heavier 90 days before calving tended to produce heavier calves at birth and throughout the suckling period. These data suggested that this association is larger for younger cows and that the pattern of change in dam's weight appeared to be subject to herd and age effects. The effect of weight of dam on 180-day weight of Hereford calves raised in privately owned herds indicated a linear relationship between calf weight and cow weight in the Angus and a curvilinear relationship in the Herefords. Records from herds in Alabama, Florida, Georgia, Louisiana, North Carolina, SouthCarolina, and Texas have been included in a regional cow weight study. Preliminary analyses include weight of the cow when she calved, when her calf was weaned, or both. Analyses of these data indicate that cow weight increased with each year's increase in age up to nine years of age, the limit of these data, but the rate of increase was less with age. Cows not parous the previous year weighed 56 pounds more than parous cows at calving and 21 pounds more at weaning. Fall-calving cows were heavier than spring-calving cows. All sources of variation including location-year, breed within location-year, progeny within sire, age of dam, and previous parity, plus calving month per weight at calving were significantly different. The heritability estimate of cow weight was 0.96 at calving and 0.74 at weaning. Data from

the Arkansas station gave heritability estimates for mature cow weight of 0.44; wither height, 0.41; hip height, 0.69; shoulder width, 0.40; hip width, 0.11; chest depth, 0.71; rear flank depth, 0.39; heart girth, 0.46; and body length, 0.48. These data indicate that progress could be made in selection for cow size and/or components of cow size.

2. Carcass characteristics

Continued analyses by the Tennessee station of data from British, Zebu, and dairy steers used for beef indicate significant differences in almost all carcass composition characteristics. Among seven breeds used--Angus, Brahman, Brahman-cross, Hereford, Holstein, Jersey, and Santa Gertrudis--the short-shanked, blocky, thickly-fleshed Angus carcasses had the lowest percent separable muscle, separable bone, moisture, protein, round + loin + rib + chuck, and foreshank; with the highest percent separable fat, ether extract, and brisket. The long-shanked, long-bodied Holstein carcasses produced the highest percent separable muscle, separable bone, moisture, protein, round, and foreshank, the highest percent separable muscle and bone within all except two wholesale cuts, and were lowest of all breeds in percent separable fat of the entire side, ether extract, flank, and separable fat in all but one wholesale cut.

Also at the Tennessee station, data from 15 bull-steer-heifer trios indicated that bulls gained faster and more efficiently than steers or heifers and steers gained faster and more efficiently than heifers. However, bull carcasses graded lower than steers and heifers and bull meat was less tender, darker, and coarser textured than meat of the other sexes. At the Arkansas station a comparison of multiple correlations using feed consumption, initial weight, and indicators of carcass leanness indicated that about 16 percent of the variance of gain was associated with round and loin weight, rib-eye area, and fat thickness. On a constant weight basis, forequarter and chuck were significantly related to gain.

3. Reproduction

Continuation of research at several stations on differences between breeds and reproductive rates, as well as an S-10 regional fertility study, gives evidence that even though calculated heritabilities for various measures of fertility are low, breed differences still exist. Data from a Louisiana study showed large differences in calving percent between breeds and crosses, although these were not significant, due to large within-group variation. Selective mating of Brahman sires was indicated by differences in calving percentage when Brahman bulls were used on British cows, as compared to British × British, Brahman × Brahman, and British bull × Brahman female matings.

In contrast with previous evidence that heritability estimates of fertility are low, the Florida station has found heritability estimates of calving percentage to be considerably higher than previously

reported. These estimates, which were made from data from cooperator herds, were in the neighborhood of 0.3 to 0.6.

Additional information on the age at puberty in straightbred and crossbred heifers at the Louisiana station indicated that breed crossing results in an appreciable amount of heterosis for this trait. A number of crossbred heifers have calved at two years of age and have done so with little difficulty. Previously this station had reported little evidence of heterosis for puberty, in contrast to British breed crossing results at the Nebraska station where a positive heterotic effect had been reported.

4. Crossbreeding

A major portion of the Southern Regional Beef Cattle Breeding Project has been and continues to be devoted to the study of crossbreeding beef cattle. A study recently completed at the Louisiana station indicated that reciprocal cross cows resulting from wide crosses are not equally productive insofar as weaning weight of their calves is concerned. When the breeds involved in the original crosses are similar, the reciprocal crosses themselves are quite similar in productivity. It is quite possible that the difference between reciprocal-cross cows is due to a permanent effect of their own early maternal environment. At the same station, a summary of calving dates and calving percentages by various sire-dam-breed combinations indicates that Brahman bulls show some degree of selectivity as to the kind of cattle with which they mate. Observation of the breeding behavior of Brahman bulls over the past 12 years has brought out the fact that some Brahman bulls definitely show strong preference for Brahman-type cows.

Several stations have been comparing different systems of mating for several years. The Georgia station has completed one generation of a comparison of grading up, crisscrossing, and three-breed rotational crossing. The cows of the crisscrossing and three-breed rotational systems have had a weaning percentage advantage of approximately 3 percent over the grades. There has been little difference in the three systems in percentage of calf crop born, indicating that the crossbred calves have a higher survival rate than do the straightbred calves.

A crossbreeding study at the Alabama station comparing two-breed crosses with three-breed crosses indicates an advantage at weaning time of approximately 23 pounds in favor of three-way cross steers. However, no differences were noted in postweaning performance. Smaller differences were obtained in heifers than in steers. A separate study at the same station indicated that the crossbred cows weaned a higher percentage of calf crop and remained in production longer than did straightbred Hereford controls.

In a study of combining ability of Angus sires at the Brooksville station, a definite sire × breed interaction was indicated. One Angus

bull sired better crossbred calves than he did Angus calves, and another bull sired better Angus calves than he did crossbred calves. In order to determine whether this ability is passed on to their offspring, sons of the two interaction bulls are presently being used in a progeny test.

Differences between breeds in viability of calves has been noted at the Jeanerette station where the average mortality during the first 72 hours after birth was 5 percent. Calf death losses were as high as 22 percent during the first month following birth for the Brahman breed; whereas, calves resulting from Brangus cows, i.e., crossbred foundation or three-breed cross calves resulting from Brangus bulls on F_1 cows, had a much higher survival rate.

5. Selection

Several long-time experiments on the progress of selection for specific traits over a period of generations are being continued. In a preliminary report from the Georgia station where Generation 1 cows from four selection lines, i.e., (1) weaning weight, (2) rate of post-weaning gain, (3) weaning score, and (4) average performance, were compared to foundation cows set up in each of these lines, calves from the foundation cows in each of these lines were superior in growth rate.

6. Genetic-environmental interactions

Work on genetic-environmental interactions is being continued in two studies in the S-10 region, one a cooperative effort between the Brooksville, Florida, and Miles City, Montana, stations and the other at the North Carolina station. Since both of these studies are still relatively new, few results have been analyzed. At the North Carolina station the data indicate that sire × location interactions for evidence of genotype-environmental interactions are small. The cooperative study between Brooksville and Miles City is only in its fourth year, and, as yet, it gives no concrete evidence of genetic-environmental interactions. There was a large contrast this year between the calving percentages of Miles City cattle transported to Florida, in comparison to cattle of the Miles City line raised in Florida and the Hereford cattle that have been at Brooksville for several generations.

7. Genetic defects

Embryology studies of dwarf and normal genotypes are being made at the Florida station in order to bracket the age that the abnormality first occurs. These studies are relatively new, and no results are yet available. Cytological studies to date have shown no differences in genotypes.

Even though no other detailed experiments concerned with snorter dwarfism are being carried on at other stations, studies of pedigrees

in regard to dwarfism are continually being made. Another snorter dwarf calf was born in 1964 at the Front Royal station. This calf, a crossbred, was by a cow which was the double great granddam of a snorter calf born in 1963. The cow was bred artificially to a Hereford snorter dwarf bull in an effort to prove she was a carrier.

In general, the S-10 Regional Beef Cattle Breeding Project will be continued as outlined in the project revision along the lines of selection, breeding systems, beef quality and carcass work, studies of genetic abnormalities, and projects of related interest. A regional publication is planned on the reproduction of beef cattle in the South.

UNIVERSITY OF ARIZONA

I. Station: Arizona Agricultural Experiment Station, Tucson

II. Project title: Breeding and selection of beef cattle for the Southwest

III. Personnel:

Experiment station:
C. B. Roubicek, Project Leader, L. W. Dewhirst, A. M. Lane, D. E. Ray, and B. R. Taylor

Graduate students:
R. L. Taylor and T. O'Kane

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
J. S. Brinks, Investigations Leader

Cooperators:
Apache Indian Agency and Apache Tribe, San Carlos, Arizona
W-1 cooperating stations

IV. Nature and extent of work done this year:

1. Continued collection of data as outlined in the project plan.

2. Proceeded with Line Test Program. Semen from test bulls has been collected and shipped to cooperators. Cows have been randomly allotted to breeding pastures for the Line Test Program.

3. Analyses of blood constituent data are continuing. Data on plasma cholesterol in the bovine have been prepared for publication.

V. Summary of progress:

A very complete summary of progress through 1963 was prepared for the last annual report. Additional information is now available for plasma cholesterol.

Least squares analyses of plasma cholesterol concentrations have been carried out to estimate the means and variability of plasma cholesterol concentration at four stages of development in Southwestern range Herefords. In addition, within-subclass correlations were computed between plasma cholesterol concentrations at four stages of development and between plasma cholesterol and subsequent growth traits to estimate any relationship existing between them. Genetic, environmental, and

phenotypic correlations were estimated where possible. The 1959 and 1960 bull and heifer progeny of a herd of registered Herefords maintained under typical semiarid range conditions were used in the study. The numbers of animals contributing to each block of data were, for the bull and heifer progeny, respectively, 235-day, 167 and 167; 340-day, 110 and 150; 600-day, 99 and 133; 710-day, 86 and 109. Twelve sires were represented with ten of them contributing offspring in both years of the study.

Because of the fact that plasma cholesterol concentrations have been determined on a fairly large sample of range Herefords under ordinary range conditions, perhaps the most important or significant contribution of this study is the estimation of means and variability to be expected under range conditions comparable to those found in Arizona.

Investigation of factors influencing plasma cholesterol concentration in range cattle indicates that environmental conditions associated with year of birth may exert significant effects upon cholesterol concentrations in the blood. The 710-day block of data indicates a possible sex by year interaction in this respect. No effect of age-of-dam influence was detected. Age of animal within a sampling period showed no significant effect with the exception of the bull progeny at 235 days of age. Analysis of genetic influences on plasma cholesterol concentrations was inconclusive in this study. Between-sire variance exceeded the within-subgroup or error variances in six of the eight analyses, but to a significant degree in only two cases, i.e., the heifer data at 235 and at 600 days of age.

No reliable indications of relationship between plasma cholesterol concentrations and subsequent concentrations or growth traits were found in this study.

VI. Publications and manuscripts:

Roubicek, C. B. 1963. Climate and Livestock Production. In Aridity and Man. Washington, D. C. (American Association for the Advancement of Science. Publication No. 74.)

VII. Project summary:

Arizona Agricultural Experiment Station

Cattle Inventory - fiscal 1964-65	
Breed	Hereford
Purebred or grade	Purebred
Bulls - 12 months or over	84
Cows - 2 years or over	502
Heifers - yearlings	140
Calves - bulls	152
- steers	0
- heifers	166

Cow Production Data - 1964 calf crop	
Breed	Hereford
Number of cows bred to calve	
As 2-year-olds	0
At 3 years and up	448
Number of calves born from	
3-year-olds and up - alive	318
- dead	4
- total	322
Number of calves weaned	296
Percent calf crop - born[1]	84
- weaned[2]	78

Preweaning Performance - 1963 calf crop	Bulls	Heifers
Birth weight - pounds	82	76
Weaning age - days	250	250
Weaning weight - pounds	465	439
Adjusted weaning weight[3]		
Weaning score[4] - condition	10	11
conformation	10	11

Note: Due to extended drough, animal numbers were generally reduced

[1]Based on calves born alive and exposed cows still in the herd at calving time

[2]Corrected for dry cows and cows with calves at side sold prior to weaning

[3]Not computed

[4]Scores of 10, 11, and 12 are low, middle, and high choice feeder grade

UNIVERSITY OF CALIFORNIA

I. Station: California Agricultural Experiment Station, Davis

II. Project title: Studies of heterotic effects in crosses of the Angus, Hereford, and Shorthorn breeds

III. Personnel:

Experiment station:
W. C. Rollins, Project Leader, F. D. Carroll, R. G. Loy, Allan Grunder, and K. A. Wagnon

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
J. S. Brinks, Investigations Leader

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

The experiment proceeded according to plan except that one Shorthorn bull (instead of two) was used during the third breeding season.

A. Percent conception, based on palpation two months after the breeding season, showed hybrid vigor of 10 percent, 13 percent, and 4 percent, respectively, for the Angus × Hereford, Angus × Shorthorn, and Hereford × Shorthorn crosses

Over the three breeding seasons, Angus, Hereford, and Shorthorn cows, respectively, averaged 81 percent, 78 percent, and 65 percent conception.

B. Postweaning growth of first calf crop (sired by Angus bulls) (see tables 1 and 2)

VI. Application of findings:

Too early to report

VII. Work planned for the future:

The work at the range will proceed according to plan except that one bull in natural service will be used each year instead of artificial insemination. Management conditions have dictated this change.

At Davis, the three planned breeding seasons have been completed. The second calf crop is being grown out and the third is in

Table 1. Performance Comparisons of AH and AS Crossbreds, Respectively, with AA Straightbreds

	Overall average	AH-AA	(AH-AA) × 100 / AA	AS-AA	(AS-AA) × 100 / AA
			Percent		Percent
240-day weaning weight	415	22	5.6	36	9.1
Weaning grade	88	0	0	1	1.1
Postweaning gain:					
Bulls and steers in feedlot	440	75	18.4	23	5.7
Heifers in dry-lot at Davis	218	26	13.7	58	30.5
Heifers on range	45	26	68.4	-5	-13.2
Age-adjusted yearling weight:					
Bulls and steers in feedlot	865	118	14.7	69	8.6
Heifers in dry-lot at Davis	628	36	6.3	132	23.1
Heifers on range	450	14	3.1	-25	-5.5
Dressing percent - bulls and steers	59.9	0.5	0.8	0.9	1.5
Carcass weight	516	72	15.3	65	13.8
Carcass grade - bulls and steers	18.0	0.2	1.1	1.4	8.0

Table 2. Performance Comparisons of Bulls with Steers

	Overall average	Bulls-Steers	(Bulls-Steers) × 100 / Steers
			Percent
240-day weaning weight	425	21	5.1
Weaning grade	88	1	1.1
Postweaning gain	440	23	5.4
Age-adjusted yearling weight	865	44	5.2
Dressing percent	59.9	-.2	-.3
Carcass weight	516	23	4.6
Carcass grade	18.0	-1.0	-5.4

dam. The study of relation of age and weight to the onset of puberty in heifers was not done with the first calf crop as planned but is being done with the second.

A new breeding project for Davis is being designed.

VIII. Publications and manuscripts:

Rollins, W. C. and F. D. Carroll. 1964. Progeny testing bulls. Calif. Agr. 18(9):11-12.

Rollins, W. C. 1965. Progress report: Crossbreeding Angus, Hereford, and Shorthorn cattle. Beef Day Program, University of California, Davis. pp.33-37

*Rollins, W. C. and F. D. Carroll. 1964. Live performance and carcass trait comparisons of crossbred with straightbred Herefords and Angus calves. Calif. Agr. 18(10):14-15.

*Carroll, F. D. and W. C. Rollins. 1964. Performance comparisons of Charbray and Hereford cattle and crosses between them. Calif. Agr. 18(11):4-6.

*Carroll, F. D. and W. C. Rollins. 1965. Performance of Charbray and Hereford cattle and crosses between them. Animal Prod. 7:119-126.

*Sharrah, Nancy, Marion Simone Kunze, and Rose Marie Pangborn. 1965. Beef tenderness: Sensory and mechanical evaluation of animals of different breeds. Food Tech. 19:131-136.

*Project 1938 - W-1 affiliated project, completed during 1962-63

IX. Project summary:

California Agricultural Experiment Station

Cattle Inventory

Breed	Angus	Here-ford	Short-horn	Crossbreds A×H	A×S	H×A	H×S
Cows	26	22	25				
Bulls[1]		2					
Calves		13				17	11
Yearlings	17			22	16		

[1]Vasectomized

COLORADO STATE UNIVERSITY

I. Station: Colorado Agricultural Experiment Station, Fort Collins

II. Project title: Study of selection, inbreeding, and the crossing of inbred lines within the Hereford breed (R & M 26)

III. Personnel:

Experiment Station:
H. H. Stonaker, Project Leader, Kent Riddle, Tom Hall, L. J. Theurer, and Glenn Richardson

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado:
J. S. Brinks, Investigations Leader

IV. Nature and extent of work done this year:

A. Selection results:

In his Ph. D. dissertation, J. B. Armstrong showed relatively high heritabilities and positive selection differentials for the weaning weight, daily gain, and grade in the San Juan Basin herd. However, in contrast to an expected positive genetic change, analyses using repeat mating information indicated regression rather than progress in traits other than grade. The selection index on which these cattle were selected during the 18 years reported was for weaning weight and daily gain. The reason for the great discrepancy between expected and achieved results from selection in this herd, as based on the technique of repeat matings, is not readily apparent.

B. DNA Content of individual sperm cells:

Through the cooperation of Dr. G. W. Salisbury and Dr. Fred Baker of the Dairy Science Department, University of Illinois, semen samples of 80 bulls were taken at the station in May. The high level of variability in observations on semen has raised the point of whether the variation in evidence of semen quality due to inbreeding may be associated with variation in DNA content of single sperm cells. The hypothesis is that there may be greater variability in DNA content of individual sperm cells in bulls with low fertility levels than in those with high fertility levels. This is based on studies in man by Leuchtenberger.

C. Chromosome numbers of the white blood cells:

A correlary of Dr. Salisbury's study is that of Dr. N. S. Fechheimer, Department of Dairy Science, Ohio State University, Columbus, Ohio. Blood samples were collected by Dr. Fechheimer and tissue cultures initiated on 40 different inbred and linecross bulls at the San Juan Basin Station. Semen samples from these same bulls were taken earlier by Dr. Salisbury and Dr. Baker. In addition, a blood sample was taken of an intersex heifer. The purpose of the tissue cultures is to make possible chromosomal counts of these cells from these various sources of cattle. It is hypothesized that there may be parallelism between the variability in chromosome numbers as indicated in the white blood cells and the DNA content of sperm cells. A second hypothesis is that intersexuality in heifers, such as indicated in this particular case, may be due to an abnormal karyotype.

D. Predicted breeding soundness in bulls:

An analysis is in progress of the factors contributing to predicting breeding soundness of bulls as a result of semen evaluation. Approximately 70 observations are available for analysis on inbred, linecross, crossbred, and other bulls which have accumulated on over 1,000 yearling bulls during the past years. Analyses will include heritability estimates, comparisons of mating systems, year-to-year variations, and ration effects.

E. Carcass traits of cows:

Analysis is being made of the carcass traits of cows of varying ages and lines of breeding and mating systems. This will include a number of observations on the boned-out carcasses including cooking tests and shear values. It is the purpose of this study to examine the possibility of carcass variations being more pronounced in cow carcasses than in younger carcasses.

F. Carcass characteristics of bulls and heifers:

This is a continuation of previous years of data collection on trimmed retail cutouts and of chemical and taste panel analyses.

G. Milk production of inbred and hybrid beef heifers:

For the second year, first-calf heifers are being milked twice daily and production records obtained along with

the chemical analysis of the milk. The purpose is to explore the effect of mating system and line of breeding on milk production.

H. Milk and feed consumption of inbred and hybrid beef calves versus dairy calves:

For the second year the calves from the heifers in the milking trial are being individually hand raised and individual feed consumption is recorded. In addition, a few dairy calves of Holstein breeding are being raised as contemporaries with the beef calves. The ultimate objective is to determine the effect of mating system and breed on efficiency and rate of growth and carcass characteristics.

I. Weaning characteristics of inbred and hybrid and crossbred calves:

Routine weights and grades of calves from various mating systems and lines of breeding are being continued as in the past.

J. Death loss and removal of cattle from the San Juan Basin herd:

A 20-year analysis of death losses and reasons for these losses or removal of cattle from the herd is being made. Again, the effects of mating system, line of breeding, age, and sex as related to these variables are being investigated.

K. Causes of increased heterosis in weaning traits of heifers over bulls:

An investigation into environmental variables as they may affect the growth of bulls versus heifers and as these effects may interact with mating system is being made. In addition, similar analyses are being conducted on the effect of crossbreeding in the Fort Wingate, New Mexico sheep. The purpose of this study is to determine whether, with many environmental variables considered, there actually is greater heterosis or hybrid vigor in weaning weights of females over males or if this is the result of environment.

L. Performance of cooperator-raised cattle:

There is a continuation of the feedlot performance of unselected bulls from the San Juan Basin Station and of a number of bulls provided by breeders in the San Juan Basin region. Two groups of bulls are tested annually. The first group of cattle are placed on a high level of energy ration following weaning, and the second group of bulls are wintered on a high roughage ration and subsequently in June are placed on high energy rations for a 140-day period.

M. Progeny testing on the San Carlos Reservation and in the Hawaiian Ranch Company herds:

Through the cooperation of the University of Arizona and the University of Hawaii, the San Juan Basin Experiment Station is providing two bulls annually for progeny testing in these herds. This is being done under the direction of the Regional Investigations Leader, Dr. Brinks.

N. Fat characteristics:

An analysis of lipids and fatty acids on slaughter cattle from the various lines has been initiated in a cooperative study with other stations in W-1.

V. Future plans:

It is hoped that the currently initiated studies on DNA and chromosomal counts can be continued. We plan to continue studies on carcass traits in cows, milk production of heifers, and the growth and feed requirements of calves from birth. These phases of work should be terminated within three or four years.

VI. Publications and manuscripts:

Armstrong, J. B. 1964. Evaluation of selection intensity and genetic changes in an experimental herd of Hereford cattle. Ph. D. Thesis. Colorado State University, Fort Collins.

Davenport, R. L., H. H. Stonaker, Kent Riddle, and T. M. Sutherland. 1965. Heritability of reproductive performance in inbred and linecross beef cows. J. Anim. Sci. 24(2):434.

Stonaker, H. H. 1964. Evaluating maternal traits and preweaning performance. Symposium. American Society of Animal Science. (Unpublished) Knoxville, Tennessee.

VII. Project summary:

Cattle Inventory - June 1965		
Breed		Hereford
Purebred or grade		Purebred
Herd bulls		14
Cows and yearling heifers		298
Calves to June 2		213
Feedlot heifers		56
Summer test bulls		28
Winter test bulls	Sold May 29	60

Colorado

Cow Production Data - 1964 calf crop	(inbreds, controls, linecrosses, and crossbreds included)			
Breed			Hereford	
Line and sire	2-139	3-86	4-105	5-117
Number of cows bred to calve				
As 2-year-olds	2	0	6	4
At 3 years and up	7	11	7	17
Number of calves born from:				
2-year-olds - alive	2		5	2
- dead	0		0	0
3-year-olds and up - alive	7	8	4	14
- dead	0	2	1	2
Number of calves weaned	9	8	9	16
Percent calf crop[1] - born	100	91	77	86
- weaned	100	73	69	76

Preweaning Performance - 1964 calf crop				
Weaning age	192	216	188	208
Weaning weight	364	478	349	410
Adjusted weaning weight[2]	453	470	439	435
Weaning score: Conformation	4.5	5.4	4.8	4.7
Average inbreeding	.42	.12	.36	.11

Postweaning Performance - 1964 calf crop				
Number on test	0	4	6	1
Days on test		140	140	140
Average daily gain		2.71	2.57	2.41
Feed efficiency:				
Lbs.feed/lb. gain		6.04	4.82	5.79
Final weight		887	722	786
Final score: Conformation		5.0	4.0	4.2
Average inbreeding		0	0	.125

Line Code: 2-Bonanza, 3-Brae Arden, 4-Colorado, 5-Don, 9-Monarch, 10-Prospector, 11-Royal, 12-San Juan, 13-Control, 14-Tarrington, 15-Real Prince, 60-Prospector Cross, 61-Royal Cross

[1]Calves born/cows exposed. Calves weaned/cows exposed.

[2]Weaning weight correction after Harwin Model 3

		Bulls	Heifers
For each 1% inbreeding of dam - add		.78 lb.	.79 lb.
For each 1% inbreeding of calf - add		.41 lb.	.24 lb.
Age of dam	2	55	63
	3	29	36
	4	14	15
	5+	No correction	

Colorado

Cow Production Data - 1964 calf crop	(inbreds, controls, linecrosses, and crossbreds included)			
Breed	Hereford			
Line and sire	9-130	10-77	11-128	11-75
Number of cows bred to calve				
As 2-year-olds	2	1	2	1
At 3 years and up	9	17	17	17
Number of calves born from				
2-year-olds - alive	1	1	2	1
- dead	0	0	0	0
3-year-olds and up - alive	9	10	14	15
- dead	0	6	2	1
Number of calves weaned	9	11	16	16
Percent calf crop[1] - born	91	100	95	100
- weaned	91	66	84	89

Preweaning Performance - 1964 calf crop				
Weaning age	216	209	176	209
Weaning weight	374	450	364	392
Adjusted weaning weight[2]	416	449	431	414
Weaning score: Conformation	4.4	4.7	4.7	4.5
Average inbreeding	.36	.22	.11	.11

Postweaning Performance - 1964 calf crop				
Number on test	1	5	1	11
Days on test	140	140	140	140
Average daily gain	2.28	2.20	2.32	2.39
Feed efficiency:				
Lbs. feed/lb. gain	5.84	6.50	5.14	6.44
Final weight	752	760	695	796
Final score: Conformation	4.0	3.9		4.3
Average inbreeding	.33	.18	.50	

Line Code: 2-Bonanza, 3-Brae Arden, 4-Colorado, 5-Don, 9-Monarch, 10-Prospector, 11-Royal, 12-San Juan, 13-Control, 14-Tarrington, 15-Real Prince, 60-Prospector Cross, 61-Royal Cross

[1]Calves born/ cows exposed. Calves weaned/cows exposed.

[2]Weaning weight corrections after Harwin Model 3

		Bulls	Heifers
For each 1% inbreeding of dam - add		.78 lb.	.79 lb.
For each 1% inbreeding of calv - add		.41 lb.	.24 lb.
Age of dam	2	55	63
	3	29	36
	4	14	15
	5+	No correction	

Colorado

Cow Production Data - 1964 calf crop	(inbreds, controls, linecrosses, and crossbreds included)			
Breed	Herefords			
Line and sire	12-132	12-136	13-143	14-107
Number of cows bred to calve				
As 2-year-olds	2	4	2	2
At 3 years and up	17	16	28	11
Number of calves born from				
2-year-olds - alive	1	3	1	2
- dead	0	0	1	0
3-year-olds and up - alive	14	10	25	7
- dead	1	3	2	2
Number of calves weaned	15	13	26[2]	9
Percent calf crop[1] - born	94	100	97	85
- weaned	79	65	87	69

Preweaning Performance - 1964 calf crop				
Weaning age	206	208	214	209
Weaning weight	407	375	425	424
Adjusted weaning weight[3]	442	397	418	450
Weaning score: Conformation	5.1	4.5	5.4	5.0
Average inbreeding	.13	.10	. 0	.30

Postweaning Performance - 1964 calf crop				
Number on test	5	3	6	4
Days on test	140	140	140	140
Average daily gain	2.51	2.64	2.28	2.61
Feed efficiency:				
Lbs. feed/lb. gain	6.04	5.60	6.55	5.34
Final weight	827	793	776	800
Final score: Conformation	4.4	4.5	4.8	4.5

Line Code: 2-Bonanza, 3-Brae Arden, 4-Colorado, 5-Don, 9-Monarch, 10-Prospector, 11-Royal, 12-San Juan, 13-Control, 14-Tarrington, 15-Real Prince, 60-Prospector Cross, 61-Royal Cross

[1]Calves born/cows exposed. Calves weaned/cows exposed.

[2]Includes 9 crossbreds

[3]Weaning weight corrections after Harwin Model 3

		Bulls	Heifers
For each 1% inbreeding of dam - add		.78 lb.	.79 lb.
For each 1% inbreeding of calf - add		.41 lb.	.24 lb.
Age of dam	2	55	63
	3	29	36
	4	14	15
	5+	No correction	

Colorado

Cow Production Data - 1964 Calf Crop (inbreds, controls, linecrosses, and crossbreds included)

Breed	Hereford			
Line and sire	15-119	60-142	61-136	Total
Number of cows bred to calve				
As 2-year-olds	5	8	0	41
At 3 years and up	17	16	8	215
Number of calves gorn from				
2-year-olds - alive	4	6	0	31
- dead	0	2	0	3
3-year-olds and up - alive	12	13	8	170
- dead	3	3	0	28
Number of calves weaned	16	19	8	200
Percent calf crop[1] - born	86	100	100	91
- weaned	73	79	100	78

Preweaning Performance - 1964 calf crop				
Weaning age	203	208	186	204
Weaning weight	374	436	394	402
Adjusted weaning weight[2]	396	458	412	430
Weaning score: Conformation	4.7	4.9	4.8	4.8
Average inbreeding	.17	0	0	

Postweaning Performance - 1964 calf crop				
Number on test	10	3	3	
Days on test	140	140	140	
Average daily gain	2.29	2.71	2.38	
Feed efficiency:				
Lbs. feed/lb. gain	6.07	6.27	6.38	
Final weight	723	902	795	
Final score: Conformation	4.1	4.5	4.3	

Line Code: 2-Bonanza, 3-Brae Arden, 4-Colorado, 5-Don, 9-Monarch, 10=Prospector, 11-Royal, 12-San Juan, 13-Control, 14-Tarrington, 15-Real Prince, 60-Prospector Cross, 61-Royal Cross

[1]Calves born/cows exposed. Calves weaned/cows exposed.

[2]Weaning weight corrections after Harwin Model 3

		Bulls	Heifers
For each 1% inbreeding of dam - add		.78 lb.	.79 lb.
For each 1% inbreeding of calf - add		.41 lb.	.24 lb.
Age of dam	2	55	63
	3	29	36
	4	14	15
	5+	No correction	

COLORADO STATE UNIVERSITY

I. Station: Colorado Agricultural Experiment Station

II. Project title: Heritability of various components of serum lipids and their effects on the composition and distribution of fat in beef cattle

III. Personnel:

D. A. Cramer, J. S. Brinks, and L. G. Miller

IV. Objectives:

1. To determine the heritabilities of the different types of serum lipids and fatty acid components of beef fat

2. To determine the genetic relationships of various types of lipids in total serum lipids with fatty acid composition of beef fat and distribution of fats (marbling fat vs. waste fat) in beef catcasses

3. To improve ultimately the marbling/waste fat ratio in beef cattle by selection based on blood serum analysis

V. Progress of work:

Most of the quantitative chemical techniques involved in this research have been developed. Thus far, we have received samples from the following stations:

Colorado Agricultural Experiment Station, Fort Collins	26 samples
Montana Agricultural Experiment Station, Bozeman	7 samples
New Mexico Agricultural Expt. Station, University Park	29 samples
U. S. Range Livestock Expt. Station, Miles City, Montana	35 samples
Washington Agricultural Experiment Station, Pullman	12 samples

Table 1 is a summarization of the average percent ether extract and iodine numbers of intramuscular, inner and outer subcutaneous fat from Miles City bulls by sire. There appears to be some variation among sire groups in the composition of the fat as indicated by iodine numbers. These data indicate there is considerable variation between inner and outer subcutaneous fat and between inner, outer subcutaneous and intramuscular fat within each sire group.

Table 1. Average Iodine Numbers and Percent Ether Extract of Steak Samples by Sire at the Miles City Station

	Iodine Number			Percent Ether Extract		
	Intra-	Subcutaneous		Intra-	Subcutaneous	
Sire	muscular	Inner	Outer	muscular	Inner	Outer
Florida A Sire 9111	54.8	40.9	47.3	19.2	93.3	68.9
Florida B Sire 9112	53.0	46.7	50.5	15.9	90.9	76.8
GEIA Sire 1139	52.1	45.4	49.0	16.3	87.6	76.1
GEIB Sire 1220	52.4	44.7	47.8	10.3	85.5	84.3
GEIC Sire 1215	52.2	44.5	47.2	18.9	90.8	71.7
Carcass No.1 Sire 1273	54.2	46.2	48.7	13.8	89.5	83.6
Carcass No. 2 Sire 2357	51.4	43.8	47.5	20.3	90.9	84.2
Average of 35 bulls	52.9	44.6	48.3	16.4	89.8	77.9

V. Work planned for next year:

Serum and steak samples will be collected from the W-1 contributors. Chemical analyses will be completed on the samples on hand.

UNIVERSITY OF HAWAII

I. Station: Hawaii Agricultural Experiment Station, Honolulu

II. Project title: The estimation of genetic and phenotypic parameters in populations of beef cattle in Hawaii and their uses in selection programs (201)

III. Personnel:

Experiment station:
Estel H. Cobb, Project Leader, Oliver Wayman, Isaac I. Iwanaga, Kiyoichi Morita, Diedrich Reimer and Artemio A. Ovejera

Hawaii Ranch Company:
Tom Liggett and Carl Bredhoff

U. S. Department of Agriculture, Agricultural Research Service.
Fort Collins, Colorado:
J. S. Brinks, Investigations Leader

IV. and V. Nature and extent of work done this year and summary of progress:

Weights and grades on the 1964 calf crop were obtained as scheduled except for 12-month weights and grades. The 12-month weights and grades have been dropped. Twenty-four bulls were selected and shipped to the University of Hawaii Research Farm on Oahu for post-weaning evaluation including slaughter and carcass information.

Work was initiated at Hawaiian Ranch Company in cooperation with the University of Arizona and the U.S.D.A. Agricultural Research Service to evaluate the importance of genotype $\times$ environment interactions in beef cattle breeding. In the 1965 breeding season, 135 2-year-old replacement heifers were divided into six sire groups. One group was bred by natural service to one of the locally produced Record of Performance bulls. Four groups were inseminated using semen from the Arizona test. The four bulls used were Clay's Supreme 33 (Bozeman), L4 Mischief 100 (Miles City), K.C. E311 (Nevada), and Royal 0006 (Colorado). The sixth group was bred by artificial insemination to an International Beef Breeders bull, P. S. Pawnee Mixer 162.

The artificial insemination work involved 106 heifers and began on January 12, 1965 and ended on February 23, 1965. The heifers were well grown out and in excellent flesh. There were a total of 187 services performed. The result will not be known until calving. Some changes in the breeding program are planned for next year to permit a closer observation of females for heat.

A similar trial was initiated at Kahua Ranch Company, Ltd., involving approximately 290 cows. These cows were assigned to six breeding groups and bred to the six bulls in the Arizona test that had suitable semen for shipping. The bulls used were Reno E 307, Royal 0006, Clay's Supreme 33, K.C. E311, Gillette Arden 71, and L4 Mischief 100. Some difficulties were encountered with heat detection. There were 241 services performed on 165 cows. The remainder of the cows were not detected in heat. It was concluded that the breeding was started too soon after calving. The cows will be flushed next year prior to breeding. At least 24 cows were bred to each bull.

VI. Application of findings:

A Hawaii Beef Cattle Improvement Program is being set up and will be based on research results from this project.

VII. Work planned for the future:

The work in cooperation with Arizona and the U.S.Department of Agriculture which was initiated during the year to determine the importance of genetic-environmental interactions will be continued for another three years. Records will be kept on birth date, sire, dam, weaning weight, weaning grade, and postweaning weight and grade on all calves produced in this phase of the project. Carcass information will be obtained on some of the male progeny from each sire. Up to ten sires will be used each year depending on the number of sires producing satisfactory semen.

VIII. Publications and manuscripts:

Cobb, E. H. and A. Ovejera. 1965. Predicting yield of trimmed retail cuts in beef carcasses. Amer. Soc. Anim. Sci. West. Sect. Proc. 16:XXX.

Ovejera, Artemio A. 1964. Cutability of beef as influenced by various live animal and carcass characteristics. M. S. Thesis, University of Hawaii, Honolulu.

IX. Project summary:

Hawaii Agricultural Experiment Station

Cattle Inventory - June 1965	
Breed	Hereford
Line	Hawaii Ranch Co.
Bulls - 12 months or over	130
Cows - 2 years or over	424
Heifers - yearlings	155
Calves - bulls	171
- heifers	148

Cow Production Data - 1964	
Number of cows bred to calve	
At 3 years and up	403
Number of calves born from	
3-year-olds and up - alive	370
- dead	20
Number of calves weaned	328
Percent calf crop - born[1]	86.8
- weaned	81.4

[1]Based on number of cows exposed to bull and number of calves born alive

Peweaning Performance - 1964 calf crop	
Weaning age - bulls	241.9
- heifers	240.0
Weaning weight[1] - bulls	421.8
- heifers	402.2
Adjusted weaning weight[2] - bulls	422.9
- heifers	402.1
Conformation score[3] - bulls	4.38
- heifers	4.22

[1]Weighed after an overnight shrink

[2]Adjusted 240-day weight $= \left(\frac{\text{weaning weight - 70}}{\text{age in days}} \times 240\right) + 70$

[3]Based on a grading system where 9 is the highest and 1 is the lowest

I. Station: Hawaii Agricultural Experiment Station, Honolulu

II. Project title: A study of heterosis from crosses among breeds of beef cattle (211)

III. Personnel:

Experiment Station:
Diedrich Reimer, Project Leader, Estel H. Cobb, and Oliver Wayman

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado:
J. S. Brinks, Investigations Leader

IV. Nature and extent of work done this year:

Experiment station facilities have been under construction during the past year and are now largely completed for handling the beef cattle breeding herd.

The breeding herd was assembled as follows:

Bulls - 3 Herefords, registered, 2 years old, purchased from H. Carter, Hawaii
3 Angus, registered, 2 years old, purchased from California breeders
2 Charolais, registered, 7 years old, purchased from Hawaiian Ranch Company, Hawaii

Heifers - 60 Herefords, grade, two years old, purchased from Hawaiian Ranch Company, Hawaii
35 Angus, grade, 2 years old, purchased from Kahua Ranch, Hawaii

The breeding plan called for the use of a minimum of 50 Angus heifers. At the time of purchase, only 35 Angus females of the desired age, type, and genetic background were available. Purchase arrangements have been completed for an additional 30 Angus heifers from Kahua Ranch. These heifers will be similar in type and genetic background to the original 35 head purchased and will be included in the April 1966 breeding season.

All animals were individually identified by eartag, ear tattoo, hip brand, and neck chain. All animals were subjected to veterinary tests for brucellosis, anaplasmosis, and tuberculosis.

The breeding season started on April 2, 1965, and is scheduled to run for 75 days. Breeding herds were made up as follows:

Bulls	:	Number of cows		
Breed and number	:	Hereford	Angus	Totals
Hereford No. 101	:	10	5	15
Hereford No. 102	:	10	5	15
Angus 98	:	10	7	17
Angus 99	:	10	8	18
Charolais No. 96	:	10	5	15
Charolais Lease Bull	:	10	5	15
	:	60	35	95

Average body weights taken on April 2, 1965, were as follows:

	Bulls	Heifers
	Pounds	Pounds
Herefords	1109	764
Angus	1160	745
Charolais	1556	

V. Summary of progress and conclusions to date:

Facilities at the Mealani Experiment Station on the island of Hawaii have been completed to the point which permitted initiation of this project. All breeding stock, with the exception of the Angus bulls was purchased from local ranchers. Breeding groups were made up as outlined above. The additional Angus heifers needed to fulfill the minimum requirements for the project will be added in the fall of 1965.

VI. Work planned for the future:

The plan of work will follow the procedure shown in the project outline. Plans are in progress for the construction of feedlot facilities to permit feedlot evaluation of animals.

VII. Project summary:

This project is designed to measure the heterotic effects resulting from the crossbreeding of the Hereford, Angus, and Charolais breeds. Hereford and Angus heifers are being bred to Hereford, Angus, and Charolais bulls.

Cattle Inventory - June 1965				Total
Breed	Hereford	Angus	Charolais	
Bulls (purebred) -12 mo.or over	3	3	2*	8
Cows (grade) - 2 yr. or over	60	35	-	95

*Includes one leased bull

Cow Production Data	1965 calf crop	1966 calf crop
Number cows bred to calve at 3 yrs. and up	0	95

UNIVERSITY OF IDAHO

I. Station: Idaho Agricultural Experiment Station, Moscow

II. Project title: The improvement of economically important traits in beef cattle with special emphasis on fertility and carcass quality

III. Personnel:

Experiment station:
R. E. Christian, Project Leader, T. D. Bell, M. L. Hemstrom, L. E. Orme, C. W. Hodgson, and S. E. Slyter

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado:
J. S. Brinks, Investigations Leader

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

Eighteen bull calves (12 Hereford, 3 Angus, and 3 Shorthorn) were individually fed for 140 days following weaning to obtain feedlot gain and feed efficiency. Most of these bulls will be leased to cooperative ranchers for progeny testing.

This year, 39 steer offspring of four University bulls were purchased from two cooperating ranchers and were fed to slaughter weight in the University feedlot. The number of offspring per bull varied from 7 to 13. There was a significant difference between herds in initial weight but not between bulls within herds. None of the other production and carcass traits showed a significant bull within herd difference. These bulls were used in the same herds for a second year. Their offspring from the second year will be fed this year in the University feedlot.

The steer offspring of eight University bulls used in four cooperating herds in southern Idaho were fed to slaughter weight in a commercial feedlot. Table 1 shows the number and distribution of calves from each bull as well as a comparison of the performance of each individual bull and the average of his steer offspring. The only trait listed which showed significant sire within farm difference was the average daily gain for the first 140 days on feed.

As shown in table 2, the percentage of variation due to sire difference was very small except for the average daily gain for the first 140 days on feed. This table also shows that farm differences became less important in judging conformation after the calves were subjected to a common environment for 140 days.

The variance component analysis for the subjective conformation scores placed on the steers at weaning and just prior to slaughter are given in table 3. These data indicate that the differences due to farms become much less after the steers have been on a common environment for a period of time.

Table 1. A Comparison of Each Sire with the Average of His Progeny

Farm number	Sire number	Number calves	200-day adjusted weaning weight	Weaning score	ADG first 140 days postweaning	Final score
			Pounds		Pounds	
I	1	4	462	12.0	1.79	10.0
	Avg. of calves		328	10.5	2.12	10.7
	2	5	421	12.0	2.20	10.5
	Avg. of calves		369	10.7	2.36	11.0
II	3	4	473	12.0	2.03	12.5
	Avg. of calves		328	9.8	2.19	10.3
	4	6	422	10.0	1.94	11.0
	Avg. of calves		327	9.7	1.74	10.0
III	5	6	415	13.0	1.86	11.0
	Avg. of calves		400	10.9	2.23	9.8
	6	7	359	10.0	1.94	11.0
	Avg. of calves		431	11.0	2.08	10.6
IV	7	10	374	12.0	1.71	11.0
	Avg. of calves		435	11.8	1.84	11.0
	8	8	419	10.0	2.07	11.0
	Avg. of calves		431	11.0	2.05	10.7

Table 2. Variance Components for Certain Production Traits

Trait	Percent of total variation due to Farm	Sire/ farm	Individuals/ Sires	Heritability
200-day adjusted weaning weight	54.9	0.0	45.1	0.14
Weaning score	36.3	2.3	61.4	0.15
ADG first 140 days postweaning	0.0	36.7	63.3	1.47
Final score	7.5	2.9	89.6	0.13

Table 3. Variance Components for Initial and Final Subjective Conformation Scores

Conformation trait		Percentages of variation due to Farms	Sires/ Farms	Individuals/ sires	Heritability
Body depth	initial	58.6	2.7	38.6	0.27
	final	6.8	.4	92.8	.02
Body length	initial	60.2	.1	39.6	.01
	final	6.4	7.1	86.3	.30
Shoulder muscling	initial	58.8	.0	41.2	-.11
	final	4.7	3.0	92.3	.13
Length of rump	initial	56.5	.0	43.5	-.30
	final	33.6	6.6	59.8	.40
Depth of twist	initial	70.6	.0	29.4	-.12
	final	1.3	.0	98.7	-.01
Thickness of round	initial	64.0	1.4	34.6	.16
	final	11.8	10.3	77.8	.47
Width of loin	initial	52.2	10.0	37.8	.84
	final	9.3	12.7	77.9	.56
Width of body	initial	54.7	11.5	33.8	1.02
	final	2.7	18.6	78.6	.77
Scale and substance	initial	67.9	1.3	30.8	.17
	final	8.7	21.5	69.8	.94
Overall score	initial	62.6	3.8	33.6	.41
	final	.8	10.6	88.6	.43

VI. Application of findings:

The preliminary results from the progeny testing phase of this project would indicate that, at weaning time, it would be undesirable to compare the offspring of bulls used in different herds since much of the variation in weaning traits is due to differences between farms and very little is due to differences between sires within farms. The large farm differences are lost, however, after the steers are maintained in a common environment for a few months as is shown by the small farm variance. This program for progeny testing bulls appears to offer much promise as a practical method to be used by the purebred breeder who does not have a large number of cows which can be used for this purpose.

VII. Work planned for the future:

The progeny testing program will be continued as outlined in the project. One new cooperating rancher has been added. This rancher will use bulls of the Hereford, Angus, and Shorthorn breeds in his herd. Since he has his own feedlot, he will feed all of the steer offspring

to market weight. Although it will not be possible to obtain all reciprocal crosses in this herd, it should be possible to obtain some information on the relative merits of breed crossing in commercial herds.

A study to determine the effects of tranquilzing drugs on reproductive performance in the beef cow is being initiated. Eleven yearling heifers will be used in this study. They will be treated with various tranquilizers to determine the effect of these drugs on the reproductive process.

VIII. Publications and manuscripts:

Slyter, S. E. 1964. Heritabilities of some production traits in beef cattle and genetic correlations among these traits. M. S. Thesis. University of Idaho, Moscow.

Bell, J. J. 1965. A study of nonroughage rations for Hereford and Holstein steers with a comparison of the accuracy of live animal linear measurements and subjective scores for estimating carcass quality and composition. M. S. Thesis. University of Idaho, Moscow.

Greenwell, D. A. 1965. Subjective scores and production traits in Hereford steer calves as influenced by sires. M. S. Thesis. University of Idaho, Moscow.

IX. Project summary:

Idaho Agricultural Experiment Station

Cattle Inventory - June 1965				Total
Breed	Hereford	Angus	Shorthorn	
Purebred or grade	Purebred	Purebred	Purebred	
Bulls - 12 months or over	17	5	5	27
Cows - 2 years or over	52	29	26	107
Heifers - yearlings	14	4	5	23
Calves - bulls	22	14	10	46
- heifers	25	10	12	47

Cow Production Data - 1964 calf crop				Total
Number cows bred to calve:				
As 2 year olds	0	0	0	0
At 3 years and up	44	26	23	93
Number of calves born from				
3 year olds and up - alive	39	19	18	76
- dead	0	4	2	6
Number of calves weaned	38	19	17	74
Percent calf crop[1] - born	88.6	88.5	87.0	88.2
- weaned	86.4	73.1	73.9	79.6

[1]Percent calves born of cows bred

Preweaning Performance - 1964 calf crop				Average
Birth weight - bulls	71.8	68.4	71.4	70.8
- heifers	68.4	65.7	65.7	67.1
Weaning age - bulls	187.2	189.9	187.0	187.9
- heifers	191.1	186.7	176.3	186.3
Weaning weight - bulls	442.0	444.2	459.0	446.2
- heifers	397.4	400.2	390.3	396.2
200-day adjusted weaning weight - bulls	467.8	464.7	483.0	470.2
- heifers	441.4	453.5	467.0	450.7
Weaning score:				
Conformation - bulls	10.7	11.4	12.0	11.2
- heifers	10.9	12.0	12.0	11.4
Average inbreeding - bulls	0	0	0	0
- heifers	0	0	0	0

MONTANA STATE UNIVERSITY

I. Station: Montana Agricultural Experiment Station, Bozeman, and North Montana Branch Station, Havre

II. Project title: Recurrent selection and record of performance selection in open and closed beef cattle herds. W-1, M.S. 873, A.I. 104, North Montana Branch Station 71.

A. 1. The establishment of inbred lines of registered Hereford cattle, both horned and polled, that will result in improvement in such characteristics as rate and economy of gain, fertility, nursing ability, longevity, and carcass quality.

2. Maintain an outbred herd of Herefords with bulls selected and furnished by the purebred breeders. The bulls are to be primarily good, high scoring individuals according to breed association standards.

B. Establishment of an improved herd of registered Angus cattle in which the males are selected on a high level of performance as indicated by standard record of performance procecure.

C. Investigate the feasibility of breeding for specific combining ability through recurrent selection.

III. Personnel:

Experiment station:
Bozeman:
F. S. Willson, Project Leader, A. E. Flower, and J. R. Dynes, and R. W. Miller and N. A. Jacobsen, Extension Livestock Specialist, Consultants.

Havre:
Claude Windecker

U. S. Department of Agriculture, Agricultural Research Service
Miles City, Montana:
O. F. Pahnish, U. S. Range Livestock Experiment Station, Consultant.

Fort Collins, Colorado:
J. S. Brinks, Investigations Leader

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

Bozeman:

We used two sires in the Angus herd--one of our own top indexed bulls and a top indexed sire from the Wye Ranch in Maryland owned by the American Breeders Service. We are continuing our efforts to get topcross tests with our Angus bulls on cooperator cows. Progeny tests from one of our bulls on a cooperator's cows as compared to the progeny from a random sample of his bulls on his cows is in progress. These animals weighed about 900 pounds in mid-June. There is no significant difference in the gains of these lots so far. We had three bulls out in cooperator herds last year from which we should get calves back for our feedlot this fall. We also have put out three more bulls this summer. We expect to get feedlot and carcass information out of these tests.

We continued with our two-sire record of performance Hwreford line of cattle. We had 13 cows left of the visually selected group which we bred to an outside bulls. These animals will be used for class work only.

We indexed 14 Hereford bulls this winter, three of which were out of visually selected cows topcrossed by our ROP bulls. We indexed 12 Hereford heifers and 13 Angus bulls and 14 Angus heifers. Our bulls were self-fed this year for the first time. The identical ration was used as in previous years and we found they made about one-half pound a day greater gains than previously.

Five Angus and four Hereford yearling bulls were slaughtered. Carcass data are shown in the tabulations.

Havre:

1963-64 feeding data and carcass data are included on the Havre lines and crosslines. A problem with stiff front legs among fed Havre Line I bulls and Crossline I steers as well as a few line cows appears to be intensifying over a period of time. This problem is not a typical founder and may be centered in the shoulders.

A graduate student assigned to the Havre project has assisted the Montana State University computing center in preparing a genetic covariance program for the IBM 1620. Havre lines are being processed--both calves and matings--with this program to determine inbreeding coefficients.

VI. Application of findings:

Bozeman:

The Montana Beef Performance Association continued to grow. There are 312 active members and 51 associate members. About 375 bulls

were indexed in three private indexing centers besides the private cooperators indexing on their own ranches. Prices were not quite as good this year as they were last year.

Havre:

Genetic drift may be giving difficulty in a partially defined stiff condition of the front legs in one line. This type of problem in lines could limit usefulness of closed herd mating for the development of seedstock in cattle, or force an eventual high attrition rate among lines.

VII. Work planned for the future:

Bozeman:

Work will continue with three cooperators in three counties in the topcrossing tests with our Angus cattle. We plan to cooperate with the Arizona station by providing a bull from our ROP line at Bozeman to be used in their work with the Apache Indian Tribe. We also will get some comparative tests, we hope, through artificial insemination since this bull will be used quite extensively in Hawaii. It is hoped that we may implement wide testing of Montana station sires in cooperative tests through established artificial insemination firms.

Havre:

Arrangements have been made to furnish requested blood samples and meat (13th rib) samples to the Colorado station in a regional cooperative study.

VIII. Publications and manuscripts:

Dynes, J. Robert. 1964. Meat animal and carcass evaluation. Beef Production School Proc. December.

Willson, F. S. 1964. Review of beef cattle breeding research in Montana. Beef Production School Proc. December.

IX. Project summary:

Montana Agricultural Experiment Station

Bozeman

Cattle Inventory - June 1965				Total
Breed	Hereford	Hereford	Angus	
Line	ROP	Visual[1]	ROP	
Purebred or grade	Purebred	Purebred	Purebred	
Bulls - 12 months or over	10	3	13	26
Cows - 2 years or over	37	13	45	95
Heifers - yearlings	12	3	15	30
Steers - yearlings	10		3	13
Calves - bulls	14	6	16	36
- heifers	19	6	26	51

Cow Production Data - 1964 calf crop				Total
Number cows bred to calve:				
As 2-year-olds	12	2	12	26
At 3 years and up	26	11	39	76
Number of calves born from				
2-year-olds - alive	12	1	7	20
- dead	0	0	0	0
3-year-olds and up - alive	26[2]	9	36	71
- dead	1	0	2	3
Number calves weaned	37	10	38	85
Percent calf crop[3] - born	100	76.9	88.2	92.2
- weaned	97.3	76.9	74.5	83.3

Preweaning Performance - 1964 calf crop				
Birth weight - bulls	79.9	95	66.4	
- heifers	71.7	89	63.4	
Weaning age - bulls	189.9	180.4	198.6	
- heifers	186.5	178.6	192.6	
Weaning weight - bulls	409.9	404.3	451.7	
- heifers	376.5	415.0	423.5	
Adjusted weaning - bulls	393.0	401.7	411.6	
weight[4] - heifers	351.1	395.5	378.0	
Weaning score:				
Conformation - bulls	81.5	81.0	81.8	
- heifers	79.8	81.0	80.0	

[1]Visually selected cows × ROP sires

[2]One set of twins

[3] $\frac{\text{Cows bred}}{\text{Calves born}}$ = percent calf crop $\frac{\text{cows bred}}{\text{calves weaned}}$ = percent weaned

[4]Adjusted to 180 days

Bozeman

Postweaning Performance - 1964 calf crop						
Breed	Hereford	Hereford	Angus	Hereford	Hereford	Angus
Line	ROP	Visual	ROP	ROP	Visual	ROP
Sex	Bulls	Bulls	Bulls	Heifers	Heifers	Heifers
Method of feeding	Group	Group	Group	Group	Group	Group
Number on test	11	3	13	12	3	15
Average age on test	221.6	213.7	228.0	217.5	222.0	223.6
Initial weight	445.0	453.3	493.7	403.75	461.6	494.2
Initial score:						
Conformation	81.5	81.0	81.6	79.7	81.7	82.6
Days on test	140	140	140	140	140	140
Average daily gain	2.8	3.0	2.9	1.4	1.4	1.6
Feed efficiency:						
Feed/100 lbs. gain						
Grain	501.54	501.54	587.92			
Hay	150.62	150.62	156.36			
Total	652.16	652.16	744.28			
Final weight	832	867	897.8	596.75	664.0	718.3
Final score:						
Conformation	79.3	81.0	81.3	78.6	80.0	82.6

Carcass Data		
Fat thickness - 12th rib	0.25	0.36
Rib eye area - sq. in.	10.75	10.84
Carcass weight	541.2	520.6
Carcass grade	16	19.4

4 Hereford bulls
5 Angus bulls

Havre

Cattle Inventory - June 1965						Total
Breed			Hereford			
Purebred or grade			Purebred		Grade	
Line	HL 1	HL 2	HL 3	MC Control	MC Control	
Bulls - 12 months or over	14	14	10	7		45
Cows - 2 years or over	34	38	25	37	80	214
Heifers - yearlings	5	11	7	10	8	41
Calves - bulls	16	19	7	2		44
- steers	3	7	1		51	62
- heifers	13	8	8	3	38	70

Cow Production Data - 1964 calf crop					
Sire	813	730	739	1135	
Number cows bred to calve:					
As 2-year-olds	12	9	9	0	30
At 3 years and up	18	30	18	32	98
Number calves born from:					
2-year-olds - alive	4	3	3	0	10
- dead	3	2	2	0	7
3-years and up - alive	14	23	13	25	75
- dead	3	0	1	3	7
Number calves weaned	18	26	16	25	85
Percent calf crop[1] - born	80	71	70	87.5	77.3
- weaned	68	66	59	78	66.4

Preweaning Performance - 1964 calf crop				
Birth weight - bulls	75.1	86.3	76	89.8
- heifers	78.6	79.5	68.5	84.0
Weaning age - bulls	184.4	172.3	188	185
- heifers	180	175	182	183
Weaning weight - bulls	429	432	428	475.7
- heifers	403	410	419	460
Adjusted weaning - bulls	420	451	410	464.7
weight[2] - heifers	401	421	416	453.8
Weaning score:				
Conformation - bulls	2-	2+	2+	2+
(uniformity) - heifers	2-	2+	2+	2+
Condition: - bulls	2-	2	2	2
(desirability) - heifers	2-	2	2	2

[1] $\frac{\text{Cows exposed}}{\text{Calves born}}$ = percent calf crop $\frac{\text{cows exposed}}{\text{calves weaned}}$ = percent weaned

[2] Adjusted to 180 days

Havre

Cow Production Data - 1964 calf crop

Line and number of sire	HL 1 143	HL 1 146	HL 2 41	HL 2 64	HL 3 83	HL 3 103
Number of cows bred to calve:						
As 2-year-olds	2	2	3	2	2	2
At 3 years and up	11	11	10	11	10	10
Number calves born from:						
2-year-olds - alive	1	1	2	1	1	
- dead	0	0	0	0	1	1
3 years and up - alive	8	10	7	7	9	9
- dead	0	0	0	0	1	
Number calves weaned	9	11	9	8	9	9
Percent calf crop[1] - born	69	84	69	61	100	83
- weaned	69	84	69	61	75	75

Preweaning Performance - 1964 calf crop

Birth weight - bulls	82	82.8	82.8	82.2	93	86.8
- heifers	77	83.4	77.7	78.6	82.3	78.0
Weaning age - males	179	180	182.6	175.2	190.3	173.0
- heifers	183	180.5	185.2	170.0	180.6	183.5
Weaning weight - males	466	467	433	407	543.6	487.8
- heifers	423	453	444.7	383.6	432.6	465.6
Adjusted weaning - males	465	464.3	425.4	418	519	507.6
weight - heifers	416.6	453	432	406	431.8	456.3
Weaning score:						
Conformation - males	2+	2+	2+	2+	2+	2
(uniformity) - heifers	2+	2+	2+	2+	2+	2
Condition - males	2	2+	2	2	2+	2+
(desirability) - heifers	2	2+	2	2	2+	2+

Havre							
Postweaning Performance - 1963 calf crop							
Breed	Hereford						
Line	MC-1135	HL 1-24	HL 1-38	HL 2-924	HL 2-930	HL 3-39	HL 3-967
Sex	Steer	Steer	Steer	Steer	Steer	Steer	Steer
Method of feeding	Group	Group	Group	Group	Group	Group	Group
Number on test	15	4	2	5	7	9	6
Average age on test	181.5	172.2	169.5	174.6	173.5	176.5	168.8
Initial weight	491	447	424	496	440	486	427
Initial score:							
Condition (uniformity)	2+	2	2-	2	2	2-	2-
Conformation (desirability)	2+	2	2	2+	2+	2	2
Days on test	239	261	266	239	246	243	256
Average daily gain	2.40	2.25	2.26	2.33	2.36	2.34	2.27
Feed efficiency:							
Grain/100 lb. gain	554	576	571	555	533	576	553
Hay/100 lb. gain	130	135	134	135	132	134	135
Final weight	1066	1034	1025	1053	1021	1055	1009

Carcass Data							
Fat thickness - 12th rib	13.71	20.00	15.00	14.80	16.90	14.89	17.07
Rib eye area - sq. in.	11.11	10.06	11.83	10.48	10.64	11.46	10.86
Carcass weight	566	601	613	598	585	612	596
Cutability - percent (est. lean yield)		48.43		49.45	49.45	50.22	49.90
Carcass grade	11	15	11	13	10.6	10.9	10.3
Yield grade	3.0	3.8	3.1	3.5	3.6	3.1	3.3
Marble score	6	4+	5+	5	5+	5+	6+

Havre

Postweaning Performance - 1963 calf crop

Breed	Hereford						
Line	R.3 × HL 2	R.3 R.3	R.V × HL 2	R.V R.V	R. × HL 2	R.7 R.7	R.IX R.IX
Sex	Steer	Steer	Steer	Steer	Steer	Steer	Steer
Method of feeding	Group	Group	Group	Group	Group	Group	Group
Number on test	6	6	6	5	6	5	5
Average age on test							
Initial weight	417	421	412	427	402	390	473
Initial score:							
Condition (uniformity)							
Conformation (desirability)							
Days on test	267	261	266	280	267	274	243
Average daily gain	2.10	2.22	2.05	1.96	2.05	2.00	2.22
Feed efficiency:							
Grain/100 lb. gain	605	585	604	651	620	616	595
Hay/100 lb. gain	145	135	147	152	147	149	141
Final weight	963	1015	958	975	938	939	1012

Carcass Data							
Fat thickness - 12th rib	15.95	17.94	16.61	17.27	15.39	14.87	16.07
Rib eye area - sq.in.	11.89	10.12	11.92	11.26	11.59	12.38	10.87
Carcass weight	595	553	571	573	560	545	593
Cutability - percent (est. lean yield)							
Carcass grade	9.7	10.3	11.3	12.0	10.7	11.6	11.[illegible]
Yield grade	3.2	3.4	3.2	3.0	2.9	2.7	3.3
Marble score	6+	6+	5+	5+	5+	5+	5+

U. S. RANGE LIVESTOCK EXPERIMENT STATION

I. Station: U. S. Range Livestock Experiment Station, Miles City, Montana

II. Project titles:

AH d1-1 (Rev. 2)	Breed crossing for increased production in beef cattle
AH d1-2 (Rev. 2)	Development of superior lines of beef cattle
AH d1-41	A study of response to selection and genetic-environmental interaction in genetically similar groups of Hereford cattle at two locations

III. Personnel:

Experiment station:
U. S. Range Livestock Experiment Station, Miles City, Montana
O. F. Pahnish, Project Leader, J. J. Urick, R. A. Bellows, T. M. Riley, and G. S. Thompson

Montana Agricultural Experiment Station, Bozeman
F. S. Willson and A. E. Flower

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
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Cooperators:
Agricultural Research Service, Animal Husbandry Research Division, Beef Cattle Research Branch, Beltsville, Maryland
E. J. Warwick, Chief

West Central Florida Experiment Station, Brooksville, Florida
W. C. Burns

Florida Agricultural Experiment Station, Gainesville, Florida

IV. and V. Nature and extent of work done this year with summary of progress and conclusions:

Project AH d1-1 (Rev. 2) Breed crossing for increased beef production

The fourth and final crop of calves required to complete Phase I of the crossbreeding study was dropped in 1965. Phase I involves the crossing of Angus, Hereford, and Charolais breeds for an evaluation of first-cross progeny in comparison with straightbred stock of the three parental breeds. As an adjunct, bulls of the aforementioned breeds were used on Brown Swiss cows. Phase II, to assess the maternal ability of two-breed crosses in comparison with straightbreds, was initiated with the breeding season of 1964. Crossbred females with Brown Swiss breeding

were included as an adjunct. The first crop of calves produced in Phase II was produced in 1965. Phase III was initiated with the breeding season of 1965. This phase involves comparisons of two-breed and three-breed rotational crosses and a synthetic variety with straightbreds of the Angus, Hereford, and Charolais breeds.

Some of the data collected on the first two crops of calves in Phase I were consolidated during the past year. These preliminary results, used in a summary prepared for cattlemen and research workers interested in the project, are shown in tables 1 and 2 of Appendix I. These tables were prepared to show preliminary evidence of hybrid vigor resulting from the crossing of two beef breeds.

The results obtained on steers are shown in table 1. Here it may be seen that observed averages for the crossbreds (A×H, A×C, and H×C) consistently exceeded the expected averages for feedlot efficiency and for all growth traits except birth weight. In general, the advantages obtained through the influence of hybrid vigor on growth traits ranged from 5 to 10 percent. There was little evidence, or at least no consistent evidence, that hybrid vigor influenced dressing percentage or carcass grade appreciably. The crossbreds containing Brown Swiss breeding exceeded all other crossbreds as well as the straightbreds in weaning weight. The milk production of the Brown Swiss cows presumably accounts for at least a part of the advantage in weaning weight shown by their crossbred offspring. Postweaning growth and efficiency of feedlot gain on the crossbreds from Brown Swiss cows compared favorably with averages shown for the same traits by the straightbreds and other crossbreds. Dressing percentages and carcass grades of the crossbred steers from Brown Swiss dams were not markedly lower than the corresponding values for straightbred steers of the parent beef breeds.

The results obtained on the heifers are shown in table 2. In contrast to the results on steers, evidence of hybrid vigor in the traits observed in heifers was rather inconsistent. As was true in the case of steers, crossbred heifers from Brown Swiss cows were heavier than the straightbred heifers of the corresponding parent beef breeds at birth and weaning. These crossbreds were also considerably heavier than heifers of the parent beef breeds in weaning score and postweaning gain. Crossbred heifers with Brown Swiss breeding tended to be somewhat lower in grade at 18 months of age than were the corresponding straightbreds.

A study of age at puberty in straightbred and crossbred bulls and heifers produced in Phase I of the crossbreeding study also is in progress. Preliminary results based on information obtained on the first two crops of calves were summarized. Data on bulls showed evidence of hybrid vigor in age at puberty for all breed crosses. Bulls from Brown Swiss cows also reached puberty at a younger age than did bulls from cows of the other breeds. Data on heifers showed no consistent evidence of hybrid vigor in age at puberty. Heifers from Brown Swiss cows reached puberty at a younger age than did heifers from cows of the other breeds.

Project AH dl-2 (Rev. 2) Development of superior lines of beef cattle

A summary of performance of 14 inbred lines of Hereford cattle developed at the U. S. Range Livestock Experiment Station, Miles City, Montana, for the period 1934 through 1961 has been completed for publication. Eight of the more productive lines have been retained.

The traits studied were birth weight, weaning weight, feedlot gain, feed efficiency, 18-month weight of heifers on the range, and mature weight of cows. A summary of the performance of the various lines is shown in tables 3, 4, and 5.

Line 1 (tables 3 and 4) excelled in both weaning weight and postweaning gains. Because Line 1 is the oldest line and also the largest from the standpoint of numbers, the greatest opportunity for effective selection existed in this line. The other rather highly inbred lines (4, 6, 9, and 10) were more variable from one stage of development to another than was Line 1 (tables 3, 4, and 5).

Of the Hereford lines of cattle presently on the station, the newly formed lines 11, 12, and 14 appear to be more productive than older, more highly inbred lines. This extra production is expected to a degree since many of the calves were first crosses of inbred lines or were from dams that were first crosses, thus showing some hybrid vigor over the average of the parental lines. The Line 12 calves were heavier at birth, weaning, 12 months, 18 months, and mature ages, and better than average in efficiency of gain when compared to all other lines in the herd. The Line 11 and Line 14 cattle also were considerably above the average in all the stages of growth studied as compared to the more highly inbred lines.

Summary of Crossline Study (Phase I)

Preliminary results of the current first phase crossline study with Hereford inbred lines (1, 4, 6, 9, and 10) were summarized and are shown in table 6.

The crossline bulls were 2, 23, and 35 pounds heavier at birth, weaning, and end of feedlot test, respectively, than were the straightline bulls. This amounts to a 3, 6, and 4 percent, respectively, for the three traits. The crossline bulls gained 3 percent more than the straightline bulls during the 196-day feedlot test. The crossline heifer calves were 2, 32, and 66 pounds heavier, respectively, at birth, weaning, and at 18 months of age on the range than were the straightline heifers. Thus, the crossline heifers with a 3, 9, and 10 percent advantage at these stages of growth showed a greater amount of hybrid vigor over the straightline contemporaries than did the crossline bulls. Both the crossline bulls and heifers scored slightly higher at weaning than the straightlines.

This three-year summary of calf weights showed evidence that certain of the inbred lines when crossed had produced more hybrid vigor than other lines when compared to the average of the parental lines. The heifer offspring from the Line 4 (Husker Mischief breeding) and Line 1 (Advance Domino breeding) crosses averaged 14 and 8 percent heavier at weaning and at 18 months of age, respectively, than the average of the parent lines, while the bulls were 12 and 6 percent heavier at weaning and end of feed test. Thus, Lines 1 and 4, when crossed with each other, appeared to be one of the best "nicking" combinations of all the line crosses tested. Line 10 (Errol Domino breeding) also appears to be a promising "nicking" line. Since Lines 1, 4, and 10 also are more productive for within-line performance as compared with the other two lines tested, this strongly suggests that the greatest amount of growth will be obtained by crossing lines of superior performance.

Crossline Study (Phase II)

The first calves from the crossline and straightline heifers from the second phase of the crossline study were dropped this spring. This study was initiated in 1964 and was designed to study the maternal ability of the crossline and straightline heifers produced in the first phase. Data resulting from this study will be helpful to workers in evaluating performance of individual lines and crosslines and to provide recommendations to the industry in regard to selecting breeding stock.

Selection for Carcass Traits

The procedures followed in the development of the carcass herd were described in the last annual report. This is a comparatively recent study, and no attempt has been made yet to interpret results. A Sonoray animal tester added to the station equipment will be useful in this project.

Project AH d1-41 A study of response to selection and genetic-environmental interaction in genetically similar groups of cattle at two locations

This study initially involved an interchange of livestock between the stations at Miles City, Montana and Brooksville, Florida. The first calves from Brooksville females shipped to Miles City were obtained in 1963. As this project is just becoming well established, meaningful results obtained to date are limited.

VI. Application of findings:

The crossbreeding study (Phase I), while not yet completed, has provided preliminary evidence of the degree of influence of hybrid vigor on economically important traits of beef cattle. Subsequent phases

will determine the influence of hybrid vigor on maternal qualities and the extent to which hybrid vigor can be obtained and retained by various mating systems. This information will be of value to the segment of the beef cattle industry showing an interest in crossbreeding.

The linecrossing study is yielding information on the combining ability of beef cattle lines and is indicating the extent to which hybrid vigor can be obtained by crossing lines within the same breed.

Improvement of carcass traits is difficult because these traits are not easily evaluated in the live animal. It is anticipated that approaches to the solution of existing problems will be pointed out through the development of the carcass herd.

The genetic-environmental interaction study will indicate whether cattle developed in a given environment are limited in adaptability to other conditions.

VII. Work planned for the future:

Processing and publication of crossbreeding and linecrossing data will receive high priority as complete blocks of data from the first phase of each study become available. Phases II and III of the crossbreeding study will be continued. Phase II of the linecrossing study will be continued and Phase III will be outlined for initiation during the breeding season of 1966.

The development of the carcass study will be continued, with probable additions or revisions based on data thus far accumulated.

The genetic-environmental interaction study will be continued. This is a long-term project that has just recently progressed beyond the organization phase.

An initial test of progress made in selection of Line 1 cattle over a period of about two generations was started in the breeding season of 1965. Semen from five Line 1 bulls about one-half generation apart was available. The semen from the three oldest bulls was collected and stored in 1956. Ample semen from all bulls has been stored to permit additional tests of this kind if adequate conception is obtainable with the stored semen.

VIII. Publications and manuscripts:

Bellows, R. A. 1964. Factors affecting age at puberty in beef bulls and heifers. Montana Beef Production School Proc. December.

Bellows, R. A., R. B. Gibson, T. M. Riley, G. S. Thompson, J. J. Urick, and O. F. Pahnish. 1965. Pelvic area and body size relationships in Hereford heifers. J. Anim. Sci. 24(3):913. (Abstr.281.)

Bellows, R. A., O. O. Thomas, T. M. Riley, R. B. Gibson, N. M. Kieffer, J. J. Urick, and O. F. Pahnish. 1965. Feed effects on puberty in beef heifers. Amer. Soc. Anim. Sci. West. Sect. Proc. 16:XII.

Brinks, J. S., R. T. Clark, and N. M. Kieffer. 1964. Evaluation of response to selection and inbreeding in a closed line of Hereford cattle. U.S.D.A. Tech. B. 1323.

Pahnish, O. F. 1965. Changes in beef cattle traits--direct vs. indirect selection. (Ms. prepared for Montana Farmer Stockman)

Urick, J. J., J. S. Brinks, R. T. Clark, and F. S. Willson. 1965. History and performance of inbred lines of Hereford cattle developed at the U. S. Range Livestock Experiment Station. (Ms. prepared for Montana Agricultural Experiment Station Bulletin)

Urick, J. J. 1965. Research in breeding extended. Sunday Missoulian

<u>Presentations:</u>

Bellows, R. A. 1965. Summary of physiology research at the U. S. Range Livestock Experiment Station. Radio broadcast over KATL, Miles City, Montana.

Urick, J. J. 1965. Developing new methods of beef cattle breeding. Radio broadcast over KATL, Miles City, Montana.

Urick, J. J. 1965. Applying research findings to I.P.R. bull indexing centers. Presented at Midland Beef Test Center Sale, Billings, Montana.

Pahnish, O. F. 1965. Principles of crossbreeding beef cattle. Adult Farmers Class, Belfry, Montana.

Pahnish, O. F. 1965. Estimates responses of beef cattle traits to direct and indirect selection. North Dakota Beef Cattle Performance Association, Annual Meeting, Mandan, North Dakota.

Pahnish, O. F. 1965. Preliminary results of crossbreeding at the U. S. Range Livestock Experiment Station. Montana Charolais Association Meeting, Billings, Montana.

Pahnish, O. F. 1965. A report on crossbreeding beef cattle. Radio broadcast over KATL, Miles City, Montana.

APPENDIX I

Table 1. Growth, Carcass Grades, and Dressing Percentages of Straightbred and Crossbred Steers Phase I

Breed group	Number	Birth weight	180-day weaning weight[1]	Daily gain in feedlot	Days on feed[2]	Gain/ 100 lb. TDN	Dressing percent	Carcass grade[3]
		pounds	pounds	pounds	number	pounds	percent	points
Straightbreds:								
Angus	14	74	412	2.08	268	16.49	64.2	11.2
Hereford	11	79	401	2.14	277	18.09	62.8	13.8
Charolais	9	94	471	2.33	230	18.69	62.5	16.0
Expected crossbred averages if no hybrid vigor:								
A × H	25	76	407	2.11	272	17.29	63.5	12.5
A × C	23	84	442	2.20	249	17.59	63.4	13.6
H × C	20	86	436	2.23	254	18.39	62.7	14.9
Crossbred averages obtained:								
A × H	15	76	436	2.28	244	18.19	63.7	11.5
A × C	14	87	471	2.30	236	18.59	63.1	14.3
H × C	16	88	480	2.30	237	19.52	62.2	15.1
A × BS	11	91	500	2.17	231	17.07	62.4	12.0
H × BS	10	88	534	2.28	231	19.04	62.0	14.4
C × BS	7	105	520	2.39	209	19.28	61.7	17.1

[1]Weaning weights adjusted to constant age of 180 days
[2]Days on feed to reach actual slaughter weight of 1000 to 1050 pounds
[3]High, medium, and low choice = 8, 10, and 12, respectively; high, medium, and low good = 14, 16, and 18, respectively

Table 2. Weights and Scores of Straightbred and Crossbred Heifers
Phase I

Breed group	Number	Birth weight	180-day weaning weight[1]	Weaning score[2]	ADG weaning-18-months	18-month weight[3]	18-month score[2]
		pounds	pounds		pounds	pounds	
Straightbreds:							
Angus	12	70	412	79.6	0.99	764	75.8
Hereford	15	76	385	77.1	0.99	736	77.3
Charolais	13	90	488	78.6	1.17	903	69.2
Expected crossbred averages if no hybrid vigor:							
A × H	27	73	398	78.4	0.99	750	76.6
A × C	25	80	450	79.1	1.08	834	72.5
H × C	28	83	436	77.8	1.08	820	73.2
Crossbreds:							
A × H	34	72	403	78.3	0.99	758	76.7
A × C	41	79	443	79.7	1.10	834	78.1
H × C	28	82	450	79.8	1.11	844	78.2
A × BS	5	86	483	77.4	1.09	869	70.0
H × BS	7	84	495	79.2	1.03	860	74.3
C × BS	8	108	535	77.5	1.10	928	68.6

[1]Weaning weights adjusted to a constant age of 180 days

[2]Choice = 75 to 89; Good = 60 to 74.

[3]Adjusted weaning weight plus (daily gain after weaning × 356 days)

Table 3. Means for Birth and Weanling Traits by Lines[1]

Herd	Females				Males			
	Number of animals	Birth weight	180-day preweaning gain	180-day weaning weight	Number of animals	Birth weight	180-day preweaning gain	180-day weaning weight
		pounds	pounds	pounds		pounds	pounds	pounds
Line 1	1216	79.1	339	418	1242	83.8	360	443
Line 2	198	76.5	321	397	199	81.8	344	425
Line 3	95	80.2	316	396	108	84.3	335	419
Line 4	172	76.0	304	380	197	81.2	320	401
Line 5	181	76.2	304	380	151	78.2	317	395
Line 6	117	67.7	322	390	130	71.7	335.	406
Line 7	45	73.0	306	379	47	75.8	313	388
Line 8	45	72.6	294	366	56	79.4	313	392
Line 9	157	73.1	314	387	145	77.5	337	414
Line 10	121	80.5	315	395	130	84.3	336	420
Line 11	90	79.6	337	416	100	84.5	361	445
Line 12	85	85.2	351	436	75	89.7	360	449
Line 13	11	75.7	293	369	15	78.5	258	336
Line 14	54	80.4	335	415	69	81.6	352	433
Grade	2039	79.1	333	412	2242	84.0	349	432
Average	4626	77.0	319	396	4906	81.1	333	413

[1]Means are adjusted for year (1952-61 average), age of dam (6-year-old dam), and age of calf (180-days-of-age) effects

Table 4. Means for Postweaning Traits in Bulls by Lines[1]

Herd	Number of animals	196-day postweaning gain	Final weight off test	Feed efficiency lb.gain/lb.TDN
		pounds	pounds	
Line 1	552	478	947	21.5
Line 2	49	440	898	20.5
Line 3	19	472	938	21.6
Line 4	100	472	893	22.2
Line 5	67	450	878	21.9
Line 6	67	446	866	21.8
Line 7	17	438	858	21.4
Line 8	24	457	880	21.7
Line 9	52	443	891	21.2
Line 10	75	473	916	22.3
Line 11	54	487	961	21.4
Line 12	36	495	979	22.2
Line 13	6	493	868	25.3
Line 14	52	483	947	22.0
Average	1170	466	909	21.9

[1]Means are adjusted for year (1952-61) average, age of dam (6-year-old dam), and age of animal (376 days of age) effects

Table 5. Means for Postweaning Traits in Females by Lines[1]

Herd	Yearling weights and gains					Mature cow weights		
	Number of animals	Gain weaning-12-months	12-month weight	Gain 12-18 months	18-month weight	Number[2] of records	Spring weight	Fall weight
		pounds	pounds	pounds	pounds		pounds	pounds
Line 1	1119	94	524	264	788	2156	1231	1194
Line 2	187	93	503	257	760	391	1226	1202
Line 3	90	87	496	262	758	197	1215	1190
Line 4	164	91	485	247	732	348	1159	1124
Line 5	155	84	476	253	734	316	1160	1136
Line 6	107	88	495	237	732	232	1166	1116
Line 7	43	66	454	244	698	86	1189	1143
Line 8	45	81	458	257	715	99	1173	1137
Line 9	147	82	480	257	737	290	1188	1162
Line 10	111	99	497	265	762	241	1191	1148
Line 11	84	103	532	271	803	181	1227	1195
Line 12	76	89	530	280	810	146	1278	1234
Line 13	11	94	460	262	722	16	1159	1168
Line 14	51	102	528	261	789	122	1222	1189
Grade	1606	92	517	268	785	4142	1217	1171
Average	3996	90	486	259	755	8963	1200	1167

[1]Yearling trait means are adjusted for year (1952-61 average), age of dam (6-year-old dam), and age of animal (12-month weights, 365 days; 18-month weights, 545 days) effects; cow weights are adjusted for year (1952-61 average) and age of cow (6+-year-old cow) effects.

[2]The same cow is included each year she weaned a calf.

Table 6. Summary of Growth and Weaning Scores of Hereford Calves from Straightline and Crossline Matings for the Period 1962-1964
Phase I

	Straightline	Crossline	Advantage of crosslines over straightlines	
			pounds	percent
Bulls (preweaning)[1]				
Number	41	141		
Average birth weight	78	80	2	3
Average 180-day weaning weight	396	419	23	6
Average weaning score	78	80	2	3
Bulls (feedlot period)[2]				
Number	25	93		
Final weight at 13 months	931	968	33	4
Average daily gain	2.76	2.84	0.08	3
Heifers (preweaning)[1]				
Number	29	144		
Average birth weight	74	76	2	3
Average 180-day weaning weight	361	393	32	9
Average weaning score	77	79	2	3
Heifers (second summer on grass)[2]				
Number	19	92		
Final weight on grass (18 months)	684	750	68	10

[1]Including 3 years records
[2]Including 2 years records

IX. Project summary:

U. S. Range Livestock Experiment Station

Cattle Inventory - June 1, 1965

Breed	Hereford								Florida	Charolais	Angus
Line	L1	L4	L6	L9	L10	L11	L12	L14			
Purebred or grade	Purebred										
Bulls (12 mo. or over)	35	7	3	5	5	9	12	12	8	15	6
Cows (2 yr. or over)	135	33	28	43	36	61	61	67	37	81	64
Heifers, yearlings	24	2	6	1	5	15	25	17	14	9	12
Steer calves						4	2	3			
Bull calves	38	1	1	6	4	14	15	18	15	6	7
Heifer calves	33	5	3	6	3	12	21	13	14	10	12

Breed	Hereford	A×H H×A	C×H H×C	H×BS	A×C C×A	A×BS	C×BS	XB#1[1]	XB#2[2]	XB#3[3]
Purebred or grade	Grade									
Bulls (12 mo. or over)	15	5	5	1	5	1	3			
Cows (2 yr. or over)	254	34	27	8	40	5	8			
Heifers, yearling	81	12	12	1	13	3	4			
Steer calves	24									
Bull calves	50	17	13	2	18	5	4	4	11	7
Heifer calves	74	16	15	4	9	3	4	7	8	6

[1] C×A bull bred to H×A, A×H, C×H, H×C, H×H, A×BS, and C×BS cows
[2] A×H bull bred to H×C, C×H, H×BS, C×C, and A×C cows
[3] C×H bull bred to A×A, A×H, H×C, H×A, C×A, and C×BS cows

Cattle Inventory - June 1, 1965

Breed	Brown Swiss										
Line		4×1 1×4	6×1 1×6	9×1 1×9	10×1 1×10	4×6 6×4	4×9 9×4	4×10 10×4	6×9 9×6	6×10 10×6	9×10 10×9
Purebred or grade						Purebred					
Bulls (12 mo. or over)		5	2	2	3	6	3	4	3	2	2
Cows (2 yrs. or over)	23	12	9	10	3	13	4	7	8	11	13
Heifers, yearlings		4	4	5	7	4	7	8	5	5	6
Steer calves											1
Bull calves		10	3	3	6	4	4	4	3	5	7
Heifer calves		3	6	6	5	5	4	2	5	3	3

Breed	XLA[1]	XLB[2]	Purchased Hereford
Purebred or grade		Purebred	
Bulls (12 mos. or over)			3[3]
Cows (2 yrs. or over)			
Heifers, yearling			
Steer calves			
Bull calves	4	5	
Heifer calves	3	4	

[1]4×1 bull bred to 6×6, 4×9, 9×1, 4×6, 6×4, 9×9, 4×10, 6×1, 1×6, 10×1, and 10×10 cows
[2]6×1 bull bred to 6×9, 1×4, 9×1, 10×6, 4×1, 6×10, 4×6, 10×1, 9×6, 6×4, 4×4, and 10×10 cows
[3]Purchased three Hereford bulls and own one-half interest in fourth bull

U. S. Range Livestock Experiment Station

Cow Production Data - 1964 calf crop

Breed	Hereford										
							Crossline				
Line	1	9	10	11	12	14	1	2	3	4	5
Purebred or grade	Purebred										
Number cows bred (to calve at 3 yr. and up)	30[1]	12	11[2]	47[3]	54[4]	53[5]	31[6]	35[7]	35[8]	30[9]	30[10]
Number calves born - alive	19	9	3	40	45	40	28	32	30[11]	26	23
- dead	0	2	2	1	1	2	0	1	0	0	0
Number calves weaned	19	4	3	38	45	40	28	30	29	26	23
Percent calf crop - born	73.1	91.7	71.4	93.2	97.9	87.5	96.6	100.0	96.8	92.9	92.0
- weaned	73.1	33.3	42.9	86.4	95.7	83.3	96.6	90.9	93.5	92.9	92.0

Preweaning Performance - 1964 calf crop

Number - bulls	14	4	2	23	20	22	14	19	13	14	7
- heifers	5		1	15	25	18	14	11	16	12	16
Birth weight - bulls	78.0	68.8	81.0	89.0	88.2	80.3	84.1	82.3	78.3	77.0	79.0
- heifers	80.4		79.0	79.4	84.6	75.3	78.1	79.2	68.0	76.8	78.4
Weaning age - bulls	188.6	198.0	187.0	189.9	183.3	184.3	186.9	184.5	192.1	191.2	189.8
- heifers	196.6		176.0	190.9	187.2	185.5	182.8	187.6	189.8	185.4	190.9
Weaning weight - bulls	420.9	395.8	392.0	452.2	432.0	429.0	435.7	429.6	431.8	445.5	446.3
- heifers	396.2		365.0	416.3	394.6	396.4	399.5	416.0	367.8	399.5	427.2
Adjusted weaning - bulls	405.2	365.5	381.0	434.7	426.0	418.0	423.0	421.9	410.2	423.3	427.4
weight-180 days - heifers	369.0		371.0	397.5	382.9	385.4	395.1	403.1	353.8	389.7	408.0
Weaning score:											
Conformation - bulls	77.6	75.2	78.5	81.1	79.2	79.9	79.1	78.4	80.9	79.6	79.7
heifers	71.6		77.0	79.1	75.9	78.3	77.8	78.0	78.2	77.9	79.4

Percent calf crop computed on basis of cows remaining in herd.
[1]Three cows sold, one destroyed during breeding season. [2]Two cows sold, two died. [3]Three cows sold. [4]Six cows sold, one cow died. [5]Five cows sold. [6]Two cows sold. [7]One cow sold, one died. [8]One cow sold, three died. [9]Two cows sold. [10]Four cows sold, one died.
[11]Includes two sets of twins.

U. S. Range Livestock Experiment Station

Cow Production Data - 1964 calf crop

Breed	Crossbred								
Line	A	B	C	D	E	F	G	H	I
Number cows bred (to calve at 3 yr. and up)	26[1]	25[2]	26[3]	23[4]	22[5]	22[6]	29[7]	31[8]	30[9]
Number calves born - alive	19	19	12	16	14	15	17	25	20
- dead	1	1	1	0	1	0	0	0	2
Number calves weaned	19	18	12	15	14	15	17	24	19
Percent calf crop - born	87.0	87.0	61.9	84.2	88.2	78.9	63.0	89.3	78.6
- weaned	82.6	78.3	57.1	78.9	82.4	78.9	63.0	85.7	67.9

Preweaning Performance - 1964 calf crop									
Number - bulls	2	4	2	2	1	2	5	8	4
- steers	6	3	3	5	10	5	4	9	6
- heifers	11	11	7	8	3	8	8	7	9
Birth weight - bulls	80.0	77.0	80.5	99.5	76.0	86.0	93.4	91.4	115.8
- steers	80.5	69.0	87.7	83.6	85.4	76.8	99.0	100.3	100.0
- heifers	76.9	68.4	74.0	75.2	74.7	73.0	88.6	84.0	99.8
Weaning age - bulls	202.5	193.5	184.5	187.5	193.0	198.5	188.0	195.8	181.0
- steers	195.5	200.0	191.3	188.0	190.3	201.0	178.8	188.2	178.5
- heifers	198.0	194.1	191.1	189.4	193.0	199.0	192.1	198.8	183.2
Weaning weight - bull	499.5	523.8	504.0	507.5	541.0	538.5	509.2	501.2	527.8
- steers	487.7	423.0	422.3	475.0	484.6	519.8	497.8	531.2	482.2
- heifers	475.0	438.0	459.4	452.6	448.7	452.0	518.8	487.6	497.4
Adjusted weaning - bulls	455.0	493.8	497.0	492.5	510.0	495.5	491.6	468.8	525.2
weight - steers	455.7	387.3	402.0	459.0	463.1	474.2	503.8	512.0	490.5
180 days - heifers	439.5	410.9	438.0	433.9	425.3	415.2	491.5	449.6	492.1
Weaning score:									
Conformation - bulls	82.5	82.5	80.5	82.0	79.0	79.5	81.0	78.1	77.2
- steers	81.7	80.3	79.5	80.8	80.0	80.8	77.8	81.1	79.3
- heifers	80.3	80.3	81.4	80.1	82.3	80.4	79.6	78.7	78.0

Percent calf crop computed on basis of cows remaining in herd.
[1]Three cows sold. [2]Two cows sold. [3]Five cows sold. [4]Three cows sold, one destroyed. [5]Five cows sold.
[6]Two cows sold, one found dead. [7]Two cows sold. [8]Two cows sold. [9]Two cows sold.

U. S. Range Livestock Experiment Station

Cow Production Data - 1964 calf crop

Breed	Hereford					
Line	Florida A and B	GEI A-B-C	Carcass Herd 1	Carcass Herd 2	T1	T2
Purebred or grade	Purebred			Grade		
Number cows bred (to calve at 3 yr. and up)	31[1]	64[2]	31[3]	32	19[4]	18[5]
Number calves born - alive	25	56	29	30	12	14
Number - dead	2	2	1	0	2	0
Number calves weaned	25	54	29[6]	30	12	13
Percent calf crop - born	90.0	93.5	103.4	93.8	82.4	93.3
- weaned	83.3	89.1	100.0	93.8	70.6	86.7

Preweaning Performance - 1964 calf crop

	Florida A and B	GEI A-B-C	Carcass Herd 1	Carcass Herd 2	T1	T2
Number - bulls	11	36	10	15		
- steers					7	6
- heifers	14	18	19	15	5	7
Birth weight - bulls	77.3	85.9	86.9	90.2		
- steers					80.7	86.3
- heifers	70.7	78.9	79.8	81.2	73.6	82.4
Weaning age - bulls	189.2	188.2	184.4	182.3		
- steers					205.0	188.0
- heifers	186.1	195.2	195.7	193.5	206.2	196.9
Weaning weight - bulls	406.9	437.6	436.8	452.7		
- steers					462.1	436.3
- heifers	377.1	417.4	432.5	428.7	424.0	453.0
Adjusted weaning - bulls	390.9	422.0	429.4	449.4		
weight - - steers					416.0	422.5
180 days - heifers	365.9	391.2	403.7	406.5	379.6	420.9
Weaning score:						
Conformation - bulls	75.1	76.7	78.0	82.3		
- steers					83.0	78.2
- heifers	75.5	75.5	79.0	80.1	78.0	--

Percent calf crop computed on basis of cows remaining in herd

1One cow sold. 2One cow sold, one died. 3One cow sold, one missing and presumed dead. 4Two cows sold.
5Three cows sold.
6Includes one set of twins

Postweaning Performance - 1964 calf crop

Breed	Hereford						Charolais	Hereford Crossline				
Line	1	9	10	11	12	14		1[1]	2[2]	3[3]	4[4]	5[5]
Sex	Bull											
Method of feeding	Group - feedlot											
Number on test	14	3	2	19	18	20	5	12	17	12	12	7
Average age on test	202.6	211.7	201.0	202.3	196.7	198.8	210.0	200.8	198.9	206.2	204.0	203.9
Initial weight	425.9	391.3	391.0	448.1	425.6	429.0	582.8	446.1	438.3	435.2	445.2	458.7
Initial score:												
Conformation	77.6	75.0	78.5	81.8	79.2	80.0	80.2	78.9	78.4	80.9	78.9	79.7
Days on test	196	196	196	196	196	196	196	196	196	196	196	196
Average daily gain	2.63	2.19	2.72	2.42	2.59	2.58	2.52	2.66	2.62	2.54	2.55	2.56
Final weight	941.9	820.3	924.5	923.2	933.9	935.1	1077.2	966.8	952.0	933.2	944.6	960.8
Final score:												
Condition	77.5	75.3	80.5	76.3	78.1	76.9	77.8	78.8	77.2	77.3	78.4	78.7

Postweaning Performance - 1964 calf crop

Breed	Hereford				Crossbred								
Line	Florida	GEI	Carcass 1	Carcass 2	HXA AXH	AXA	AXBS	HXH	CXA	CXC	CXBS	CXH HXC	HXBS
Sex	Bull				Steer								
Method of feeding	Group - feedlot				Individual								
Number on test	11	34	9	15	14	6	1	2	4	7	3	8	4
Average age on test	203.2	201.4	196.3	196.3	209.6	212.3	203.0	190.5	209.5	197.9	176.3	202.1	205.8
Initial weight	406.3	427.1	450.6	460.9	456.6	464.5	509.0	420.5	498.8	506.0	536.7	512.4	558.2
Initial score:													
Conformation	75.1	76.4	79.7	82.3	74.7	82.2	78.0	79.0	80.2	78.6	79.7	81.8	81.5
Days on test	196	196	196	196	196	196	196	196	196	196	196	196	196
Average daily gain	2.37	2.44	2.40	2.50	1.94	1.68	1.67	1.95	2.03	2.22	2.05	2.05	2.06
Final weight	869.8	906.0	921.7	950.6									
Final score:													
Conformation	73.4	72.7	76.8	79.3									

[1] L1 bull bred to L1, L4, L6, L9, and L10 cows
[2] L4 bull bred to L1, L4, L6, L9, and L10 cows
[3] L6 bull bred to L1, L4, L6, L9, and L10 cows
[4] L9 bull bred to L1, L4, L6, L9, and L10 cows
[5] L10 bull bred to L1, L4, L6, L9, and L10 cows

UNIVERSITY OF NEVADA

I. Station: Nevada Agricultural Experiment Station, Reno

II. Project title: Interactions between genotype and environment in selection for economically important traits in Hereford cattle. (304 W-1). The effect of genetic-environmental interactions on selection responses. (390).

III. Personnel:

Experiment Station:
C. M. Bailey, Project Leader, J. E. Hunter, C. L. Probert, and C. R. Torell

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
J. S. Brinks, Investigations Leader

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

A. Project 304 W-1

The five lines which were established in 1955 are being continued as two-sire lines. Repeat matings were introduced this year to provide information on genetic progress. Sires from the efficiency lines (Lines 2 and 5) were sent to San Carlos, Arizona for use in the regional progeny testing program.

A total of 116 calves were performance tested. Growth rate, feed conversion, and conformation data are given in the project summary.

Part of the bulls from each line were slaughtered shortly after the conclusion of the performance tests this year. The others will be fattened to a slaughter weight of 1000 pounds. Data on feed efficiency and body composition will be obtained.

Bulls tested at the Knoll Creek Field Laboratory during 1962-64 which were not needed for breeding were shipped to Reno for further feeding. Random groups of bulls from each line (Lines 4 and 5) were implanted with 60 mg. of stilbestrol at the start of the fattening period. Performance and carcass characteristics of bulls from the two lines were similar. Least squares means according to stilbestrol treatment and standard deviations are shown in table 1.

Stilbestrol implantation caused a significant ($P<.05$) increase in the growth rate of yearling bulls on a fattening ration. However, an interaction ($P <.05$) occurred between line-of-origin and stilbestrol treatment. A satisfactory explanation of the interaction

is not available from these data, because the number in each subclass was not large and the bulls did not represent a random sample of the two lines.

Table 1. Least Squares Means and Standard Deviations of Performance and Carcass Characteristics of Yearling Bulls

Item	Least squares mean		Standard
	Implanted bull	Control Bull	deviation[1]
Number of animals	22	20	..
Initial weight, kg.	259.9	256.5	26.8
Final weight, kg.	431.9	428.6	9.6
Days on feed	125	137	34
Daily gain, kg.	1.44	1.29*	0.18
Number U.S.Choice carcasses	13	8	...
Carcass weight, kg.	259.9	258.1	9.5
Carcass fat, %[2]	16.5	16.2	2.8
Ether extract _l.dorsi_, %[3]	7.3	7.2	2.5
Warner-Bratzler shear, kg.	6.6	7.0	1.5
Tenderness[4]	6.0	5.8	1.1
Flavor[5]	5.9	5.9	0.7

[1]Within subclass
[2]% carcass fat = 487.5 - 439.8 × specific gravity of carcass
[3]1964 trial only
[4]Panel scores from 9 (like extremely) to 1 (dislike extremely)
*P <.05

Carcasses of stilbestrol-treated bulls tended to grade higher than carcasses of controls. Differences in carcass fat, and percent ether extract, tenderness, and flavor of the _longissimus dorsi_ muscle were negligible.

B. Project 390

In a preliminary study, rats representing four breeding groups were maintained on a standard diet, or on a restricted diet from 28 to 70 days of age. Males were sacrificed at 70 days of age. All females received the standard diet from 70 to 110 days of age. Males which had received the standard diet had more body fat ($P < .01$) than contemporaries which had been fed the restricted diet during the 6-week growing period. Breeding groups which were larger in body size tended to have less fat in the carcass than those which were smaller. Females which had received the low-level diet from 28 to 70 days of age made greater gains ($P < .01$) during the post-test period than females which had been maintained continuously on the standard diet.

The selection experiment consists of six lines of rats which were established from a base population of four-way crosses. Three of

the lines are maintained on a standard diet. The other three lines receive a mixture of 55 percent standard diet:45 percent cellulose during a 6-week postweaning test. Progeny in two of the lines on each diet are being selected on the basis of growth rate. The other lines serve as controls. To date, three generations of rats have been raised on the two diets. Matings for the fourth generation are in progress. Growth data have been obtained on 1,249 progeny. Preliminary results indicate that (1) dams which receive the restricted diet from 28 to 70 days of age were comparable in fertility to dams which were maintained continuously on the standard diet, (2) on each diet, progeny in the select and control lines were similar in growth rate during the initial stage of the experiment, and (3) compensatory growth occurred following the period of nutritional stress.

VI. Application of findings:

Results concerning the effect of stilbestrol on characteristics of bulls suggest that the hormone may cause a small increase in the growth rate of yearling bulls on a fattening ration. Although there is some indication that stilbestrol-treated bulls are more acceptable in carcass quality than untreated bulls, it would appear doubtful that the meat from yearling bulls is of sufficient quality to gain consumer acceptance.

VII. Work planned for the future:

The breeding program will be continued in accordance with the project outline. The efficiency and body composition of bulls tested during 1965-66 will be evaluated. Participation in the regional progeny testing program will continue. Performance test data collected during the period 1955 to 1965 will be analyzed.

VIII. Publications and manuscripts:

Probert, C. L. 1964. Performance of linebred and linecross rats and the effect of diet restriction on body composition. M. S. Thesis. University of Nevada. Reno.

IX. Project summary:

Nevada Agricultural Experiment Station

Cattle Inventory - June 1965						
Breed				Hereford		
Line[1]	1	2	3	4	5	Total
Purebred or grade				Purebred		
Bulls (12 mos. or over)	6	6	5	6	6	29
Cows (2 yr. or over)	34	34	33	33	34	168
Heifers (yearlings)	6	6	6	5	8	31
Calves - bulls	16	14	15	14	14	73
- heifers	11	12	11	11	11	56

Cow Production Data - 1964 calf crop						
Number cows bred (to calve at 3 yr. and up)	31	30	29	29	31	150
Number calves born - alive	23	24	23	21	28	119
- dead	2	2	0	1	0	5
Number calves weaned	23	24	22	20	28	117
Percent calf crop[2] - born	74	80	79	72	90	
- weaned	74	80	76	69	90	

Preweaning Performance - 1964 calf crop						
Weaning age - bulls	226	228	226	225	232	227
- heifers	227	231	226	232	231	229
Weaning weight - bulls	405	480	462	406	402	431
- heifers	418	415	426	392	406	411
Average inbreeding:						
Bulls	12	9	4	7	4	7
Heifers	10	9	6	6	4	7

[1]Lines 1, 2, and 3 - irrigated pastures. Lines 4 and 5 - range conditions

[2]$\frac{\text{Calves born alive/weaned}}{\text{Cows exposed to bull}} \times 100$

Nevada Agricultural Experiment Station

Postweaning Performance - 1964 calf crop						Total
Breed			Hereford			
Line[1]	1	2	3	4	5	
Sex			Bull			
Method of feeding			Individual - feedlot			
Number on test	12	11	11	10	13	57
Average age on test	246	248	246	243	250	247
Initial weight	404	481	464	405	404	432
Initial score:						
Conformation[2]	84.7	84.9	85.1	84.0	84.4	84.6
Days on test	140	140	140	140	140	140
Average daily gain	1.98	1.99	1.98	1.19	1.24	1.68
Feed efficiency:						
Lb.gain/100 lb.TDN	22.3	20.7	20.5	17.2	18.4	19.8
Final weight	681	760	740	572	578	666
Final score:						
Conformation[1]	85.2	85.3	85.5	83.5	83.8	84.7
Average inbreeding	12	9	4	7	4	7

Postweaning Performance - 1964 calf crop						
Breed			Hereford			
Line[1]	1	2	3	4	5	
Sex			Heifer			
Method of feeding			Individual - feedlot			
Number on test	11	12	11	10	15	59
Average age on test	247	251	246	251	249	249
Initial weight	419	416	424	390	406	411
Initial score:						
Conformation[2]	84.8	84.6	86.0	84.0	84.5	84.8
Days on test	140	140	140	140	140	140
Average daily gain	1.40	1.48	1.34	1.15	1.09	1.29
Feed efficiency:						
Lb. gain/100 lb. TDN	16.9	17.8	16.6	17.8	17.0	17.2
Final weight	615	623	612	551	559	592
Final score:						
Conformation[2]	84.5	84.3	85.6	84.5	84.1	84.6
Average inbreeding	10	9	6	6	4	7

[1]Lines 1, 2, and 3 received 2 parts grass hay:1 part concentrate ad lib. Lines 4 and 5 received 3 lb. alfalfa pellets plus grass hay ad lib.
[2]Scores from 100 (outstanding) to 67 (cull)

NEW MEXICO STATE UNIVERSITY

I. Station: New Mexico Agricultural Experiment Station, University Park

II. Project title: Inheritance of heart defects and evaluation of factors affecting production and anomalous traits in beef cattle

III. Personnel:

Experiment Station:
L. A. Holland, Project Leader, A. L. Neumann, T. H. Belling,Jr., and E. E. Ray

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
J. S. Brinks, Investigations Leader

IV. and V. Nature and extent of work done this year

Matings were planned and begun to study inheritance of a ventricular septal defect and a patent ductus arteriosus defect.

In order to change the purebred cows from year-round to seasonal calving, yearling heifers were first exposed to the bulls April 30, and will be removed July 20, 1965. Mature cows will continue to be bred year-round.

Constants for year of birth, age of dam, sex of calf, inbreeding of dam, and inbreeding of calf were determined for birth weight, weaning weight, weaning grade, and weaning condition score from 361 birth weight records during the years 1954-1963 and 431 weaning records during the years 1950-1963. Separate analyses were computed for the two lines, "old" and "outcross."

Means of birth weights and inbreeding of dam and calf are shown in tables 1 and 2. Estimates of constants for birth weight are listed in table 3. Year effects were nonsignificant. The difference between bulls and steers was not significant in the old line but was significant in the outcross line. Age of dam effects were significant for both sexes in the old line but were not significant in the outcross line analyses. The partial regressions of birth weight on inbreeding coefficients were significant only for regression of birth weight of calf on inbreeding coefficient within the outcross line. Note the regressions are positive in sign, indicating birth weights increased with increased inbreeding.

Means of weaning traits are shown in tables 4, 5, and 6.

Estimates of constants for weaning grade are listed in table 7.

Year effects were significant only in the analyses of old line and outcross males. The difference in grade between old line bulls and steers was significant. Age of dam and inbreeding effects on grade were nonsignificant in all analyses.

Estimates of constants for weaning condition are listed in table 8. Year effects were significant only in the analyses of old line males. Bulls scored significantly higher in condition than steers in both lines. Age of dam effects were significant only in the analysis of outcross line females. Inbreeding effects on condition were nonsignificant in all analyses.

Estimates of constants for weaning weight are listed in table 9. Year effects were significant in the analyses of old line males and outcross females. Bulls were significantly heavier than steers in both lines. Age of dam effects were not significant in the old line but were significant in the analyses of female weaning weights within the outcross line. Inbreeding effects on weaning weight were nonsignificant in all analyses.

Carcass data were obtained on 27 steers.

V. Summary of progress and conclusions to date:

Estimates of constants for effects of age of dam, sex, and inbreeding on birth weight and weaning traits have been obtained from data gathered under farm environmental conditions, year-round calving, and weaning at 246 days of age.

Carcass data have not been analyzed in detail.

VI. Application of findings:

A statement on application of findings should await more study of the data, including determination of selection differentials.

VII. Work planned for the future:

The birth weight and weaning traits data will be adjusted for sex, age of dam, and inbreeding. The adjusted year averages will be regressed on years. Selection differentials will be computed.

The carcass data will be analyzed.

VIII. Publications:

Moore, John Verne. 1965. Estimates of inbreeding, sex, age-of-dam, and year effects on beef calf performance. M. S. Thesis. New Mexico State University. University Park.

Table 1. Means of Birth Weights and Inbreeding of Dam and Calf in Old Line by Sex, Age of Dam, and Years

	Bulls				Steers				Heifers			
		Average				Average				Average		
	n	Weight	F_x dam	F_x calf	n	Weight	F_x dam	F_x calf	n	Weight	F_x dam	F_x calf
Age of dam:												
2	18	74.2	0.21	0.29	3	69.3	0.29	0.29	25	71.7	0.23	0.28
3	13	83.2	.21	.28	5	73.6	.19	.27	19	73.2	.21	.26
4	10	85.1	.25	.25	5	69.4	.20	.30	13	80.9	.21	.26
5	8	76.8	.16	.24	4	85.2	.20	.22	10	77.1	.18	.25
6	10	81.1	.18	.23	1	91.0	.25	.27	9	73.4	.14	.23
7	7	79.7	.15	.25	-	-	-	-	4	73.8	.14	.16
8	4	72.8	.13	.19	1	76.0	.16	.21	4	78.0	.14	.22
9	2	80.5	.10	.16	-	-	-	-	5	71.8	.18	.16
10+	10	72.3	.17	.18	1	63.0	.14	.17	11	66.0	.12	.22
Year:												
1954	2	72.0	.15	.22	-	-	-	-	1	58.0	.13	.16
1955	7	72.8	.13	.21	1	78.0	.14	.17	4	71.0	.16	.17
1956	8	71.4	.14	.22	-	-	-	-	7	70.4	.15	.22
1957	5	77.6	.14	.21	1	53.0	.25	.25	7	75.0	.14	.22
1958	6	79.0	.16	.23	1	52.0	.12	.25	12	77.0	.18	.23
1959	12	78.4	.18	.23	1	80.0	.31	.32	11	74.8	.18	.24
1960	11	75.8	.19	.24	2	83.0	.24	.25	17	73.7	.19	.26
1961	14	83.4	.23	.28	4	82.2	.24	.26	20	73.2	.19	.25
1962	11	81.8	.20	.28	7	75.4	.18	.25	12	70.5	.24	.28
1963	6	82.7	.23	.30	3	69.3	.21	.33	9	76.7	.22	.26
Total or average	82	78.4	.18	.24	20	74.7	.21	.26	100	73.6	.19	.25

Table 2. Means of Birth Weights and Inbreeding of Dam and Calf in Outcross Line by Sex, Age of Dam, and Years

	Bulls				Steers				Heifers			
		Average				Average				Average		
	n	Weight	F_x dam	F_x calf	n	Weight	F_x dam	F_x calf	n	Weight	F_x dam	F_x ealf
Age of dam:												
2	4	67.7	0.16	0.16	10	67.2	0.19	0.19	18	62.1	0.17	0.17
3	5	68.4	.16	.18	6	68.5	.13	.16	14	61.9	.17	.20
4	5	77.4	.13	.17	6	73.2	.16	.20	9	69.9	.14	.21
5	4	72.5	.17	.19	1	58.0	.18	.15	12	65.6	.12	.18
6	3	72.7	.17	.16	7	65.4	.12	.17	9	67.4	.12	.16
7	4	80.8	.13	.18	5	63.2	.11	.17	9	70.1	.14	.19
8	5	74.6	.12	.20	1	48.0	.17	.20	5	66.6	.08	.15
9	3	80.3	.11	.16	4	67.5	.09	.20	33	65.3	.09	.17
10+	1	79.0	.04	.20	2	70.0	.14	.17	4	64.5	.11	.16
Year:												
1954	1	55.0	.14	.17	5	69.2	.13	.18	3	64.7	.09	.18
1955	7	73.1	.13	.16	8	68.5	.17	.18	19	63.4	.12	.17
1956	3	80.7	.12	.19	10	63.7	.14	.16	12	64.0	.14	.18
1957	8	74.5	.16	.18	6	67.5	.11	.17	6	65.8	.14	.19
1958	5	76.8	.10	.19	2	70.0	.08	.19	7	69.0	.15	.17
1959	3	73.3	.16	.18	1	70.0	.15	.26	7	64.1	.12	.16
1960	2	77.5	.09	.19	2	55.5	.15	.16	8	62.2	.14	.17
1961	4	71.2	.18	.17	3	59.0	.16	.18	6	68.0	.16	.18
1962	-	-	-	-	3	72.0	.17	.25	9	67.8	.16	.21
1963	1	75.0	.16	.16	2	81.0	.14	.15	6	69.5	.17	.19
Total or average	34	74.2	.14	.18	42	66.9	.14	.18	83	65.4	.14	.18

Table 3. Estimates of Constants for Birth Weight

Effect	Males	Females	Males	Females
α	65	69	63	55
Year:				
1954	-3	-12	-2	-2
1955	-1	-1	0	-1
1956	-1	-2	-1	0
1957	-2	5	-1	-1
1958	2	5	1	2
1959	3	3	-2	-1
1960	1	3	-4	-4
1961	6	1	-5	4
1962	-4	-3	0	-1
1963	-1	1	14	4
Sex:				
Bulls	2	-	4	-
Steers	-2	-	-4	-
Age of dam:				
2	-8	-3	1	-5
3	0	-1	0	-6
4	1	6	5	1
5	2	4	-1	0
6	4	0	0	3
7	2	3	0	4
8	-3	4	-6	2
9	7	-4	3	0
10+	-5	-9	-2	1
Inbreeding:				
Dam	.19	.18	-.26	.16
Calf	.32	.02	.62	.52

Table 4. Means of Weaning Weight, Grade, and Condition of Bull Calves, Inbreeding of Dam and Inbreeding of Calf by Line, Age of Dam, and Years

	Old Line						Outcross Line					
		Average weaning			Average F_x			Average weaning			Average F_x	
	n	Weight	Grade	Condition	Dam	Calf	n	Weight	Grade	Condition	Dam	Calf
Age of dam:												
2	10	506	6.4	8.1	0.18	0.28	6	504	6.8	12.0	0.14	0.18
3	15	550	6.7	10.5	.19	.25	8	486	7.0	10.6	.13	.18
4	11	552	6.7	9.8	.18	.23	14	508	7.4	11.6	.11	.16
5	13	547	6.7	10.1	.16	.20	3	515	7.3	11.0	.08	.16
6	12	556	7.0	9.3	.18	.22	4	574	8.0	12.7	.05	.12
7	8	559	6.5	10.7	.16	.23	8	554	7.5	12.1	.08	.17
8	5	500	7.0	8.0	.12	.16	9	520	6.9	10.9	.08	.21
9	4	564	6.7	11.8	.08	.13	2	554	7.5	10.5	.15	.14
10+	12	519	6.7	9.5	.14	.17	-	-	-	-	-	-
Year:												
1950	1	563	7.0	14.0	.23	.04	6	537	6.5	12.3	.05	.14
1951	3	569	6.3	12.7	.08	.06	5	562	7.0	14.6	.04	.15
1952	5	532	7.0	12.0	.16	.12	7	504	6.6	11.9	.05	.16
1953	8	523	6.7	11.4	.14	.16	6	500	7.3	11.8	.11	.20
1954	2	454	5.0	3.5	.15	.22	3	509	7.3	12.0	.12	.16
1955	7	494	6.4	6.0	.12	.20	6	507	7.5	10.2	.13	.17
1956	8	466	6.0	5.8	.14	.22	6	459	7.3	8.7	.11	.18
1957	7	523	6.6	7.0	.12	.21	5	507	7.0	9.8	.16	.17
1958	5	492	7.0	9.6	.15	.19	3	498	7.0	11.3	.10	.20
1959	13	555	6.8	10.1	.17	.23	2	582	7.5	12.5	.15	.20
1960	8	550	6.7	11.1	.18	.24	1	589	8.0	13.0	.14	.20
1961	10	604	7.3	11.2	.23	.27	3	589	7.0	11.7	.17	.17
1962	8	620	7.1	12.4	.21	.27	-	-	-	-	-	-
1963	5	531	6.8	10.2	.23	.31	1	653	8.0	14.0	.16	.16
Total or average	90	540	6.7	9.8	.16	.22	54	520	7.1	11.5	.10	.17

Table 5. Means of Weaning Weight, Grade, and Condition of Steer Calves, Inbreeding of Dam, and Inbreeding of Calf by Line, Age of Dam, and Years

	Old Line						Outcross Line					
		Average weaning			Average F_x			Average weaning			Average F_x	
	n	Weight	Grade	Condition	Dam	Calf	n	Weight	Grade	Condition	Dam	Calf
Age of dam:												
2	7	427	5.9	6.0	0.20	0.19	17	438	6.5	8.5	0.16	0.18
3	5	493	6.0	8.6	.17	.18	12	429	7.0	9.6	.12	.17
4	4	495	5.8	8.5	.20	.31	9	452	6.6	8.6	.14	.18
5	3	530	6.3	11.0	.22	.17	3	439	7.0	9.3	.16	.16
6	1	583	7.0	13.0	.25	.27	7	441	7.1	8.1	.10	.16
7	-	-	-	-	-	-	5	461	7.2	10.8	.08	.17
8	2	554	6.5	12.0	.11	.12	1	313	6.0	8.0	.17	.20
9	-	-	-	-	-	-	5	478	6.8	9.8	.08	.19
10+	1	572	6.0	14.0	.21	.05	2	544	7.5	10.0	.14	.17
Year												
1950	2	480	6.5	6.5	.14	.04	-	-	-	-	-	-
1951	3	529	6.3	11.3	.20	.06	6	461	6.2	10.8	.14	.17
1952	3	496	6.0	11.0	.12	.08	4	450	6.2	7.8	.10	.17
1953	-	-	-	-	-	-	6	405	7.2	9.7	.07	.17
1954	-	-	-	-	-	-	9	456	6.8	8.3	.13	.18
1955	-	-	-	-	-	-	7	426	7.4	8.1	.18	.17
1956	1	393	5.0	4.0	.12	.25	10	444	7.3	9.7	.13	.16
1957	1	267	5.0	2.0	.25	.25	7	465	7.1	8.8	.10	.17
1958	1	400	5.0	5.0	.12	.25	1	456	7.0	11.0	.05	.15
1959	1	460	5.0	8.0	.31	.32	2	452	5.5	8.0	.14	.22
1960	1	499	6.0	6.0	.26	.26	2	469	7.0	12.0	.16	.16
1961	2	558	7.0	12.5	.20	.24	2	376	6.0	6.5	.16	.19
1962	5	514	6.0	10.2	.18	.25	3	420	6.0	6.3	.17	.25
1963	3	516	6.3	7.3	.25	.34	2	542	6.5	10.0	.14	.16
Total or average	23	491	6.0	11.0	.19	.20	61	445	6.8	9.0	.13	.18

Table 6. Means of Weaning Weight, Grade, and Condition of Heifer Calves, Inbreeding of Dam, and Inbreeding of Calf by Line, Age of Dam, and Years

	Old Line						Outcross Line					
		Average weaning			Average F_x			Average weaning			Average F_x	
	n	Weight	Grade	Condition	Dam	Calf	n	Weight	Grade	Condition	Dam	Calf
Age of dam:												
2	21	451	6.1	8.7	0.22	0.24	22	403	6.5	7.9	0.14	0.17
3	16	478	6.5	8.9	.19	.26	22	426	6.6	8.2	.14	.17
4	17	486	6.5	9.4	.18	.19	15	465	7.1	11.1	.12	.18
5	9	491	6.6	8.2	.16	.23	17	432	6.6	9.4	.11	.17
6	9	511	7.1	12.1	.14	.22	12	488	7.0	12.1	.11	.17
7	4	484	7.0	6.5	.14	.16	7	456	6.6	8.3	.11	.17
8	5	524	7.6	11.6	.13	.20	6	478	6.8	11.0	.05	.14
9	4	485	6.5	9.8	.18	.16	3	499	7.7	10.7	.13	.15
10+	9	479	6.6	8.6	.13	.19	5	419	6.2	8.4	.09	.16
Year:												
1950	2	484	7.0	12.5	.17	.04	4	480	7.3	12.5	.07	.12
1951	5	484	7.8	12.8	.15	.06	6	465	6.3	11.2	.07	.16
1952	2	460	6.5	10.0	.10	.08	13	422	6.4	8.5	.12	.16
1953	4	470	5.8	8.2	.16	.17	11	440	6.6	11.8	.09	.18
1954	3	429	6.0	7.0	.10	.20	11	409	6.4	8.3	.11	.18
1955	4	467	6.2	9.0	.16	.17	16	443	7.3	8.7	.11	.17
1956	5	433	6.2	5.8	.14	.20	9	432	6.9	8.6	.14	.17
1957	6	488	6.5	8.2	.14	.22	4	487	7.2	9.2	.12	.16
1958	9	476	6.3	9.9	.19	.24	7	421	6.4	7.9	.15	.18
1959	11	492	6.5	9.6	.18	.24	6	443	7.0	10.7	.12	.16
1960	14	474	6.6	9.2	.18	.24	5	426	6.2	9.6	.15	.16
1961	13	504	6.3	8.5	.19	.25	6	484	7.2	10.3	.16	.18
1962	9	488	6.7	9.7	.22	.28	6	480	6.8	11.0	.15	.21
1963	7	499	7.4	11.3	.20	.26	5	418	5.8	5.6	.16	.19
Total or average	94	481	6.6	9.3	.18	.22	109	441	6.7	9.4	.12	.17

Table 7. Estimates of Constants for Weaning Grade

Effect	Old Line Males	Old Line Females	Outcross Line Males	Outcross Line Females
α	6.37	7.68	6.87	6.89
Year:				
1950	.88	.12	-.38	.35
1951	.04	.74	-.31	-.54
1952	.28	-.33	-.40	-.28
1953	-.04	-.94	.52	-.14
1954	-1.93	-.46	.22	-.21
1955	-.37	-.87	.78	.56
1956	-.79	-.61	.57	.22
1957	-.07	-.18	.23	.48
1958	.11	.15	-.15	-.24
1959	.13	.27	-.54	.25
1960	.18	.38	.41	-.33
1961	.76	.06	-.27	.54
1962	.45	.61	-.54	.19
1963	.37	1.06	-.14	-.85
Sex:				
Bulls	.42	-	.17	-
Steers	-.42	-	-.17	-
Age of dam:				
2	-.24	-.64	-.30	-.18
3	-.22	.10	-.12	.00
4	-.14	-.40	-.06	.32
5	.03	-.08	-.09	-.16
6	.44	.14	-.43	.22
7	-.45	.68	.51	-.31
8	.46	.68	-.34	.01
9	.04	-.28	-.07	.52
10+	.08	-.20	.90	-.42
Inbreeding:				
Dam	-.008	-.004	-.005	-.020
calf	.001	-.047	.006	.005

Table 8. Estimates of Constants for Weaning Condition

	Old Line		Outcross Line	
	Males	Females	Males	Females
α	9.26	13.23	12.60	12.30
Year:				
1950	1.18	2.04	-.11	1.52
1951	2.93	1.74	1.92	1.03
1952	2.92	-.30	-.67	-.65
1953	1.42	-1.26	.14	1.79
1954	-6.28	-2.53	-.65	1.37
1955	3.60	-1.24	-1.04	-1.10
1956	-3.51	-4.10	-.92	-.31
1957	-3.29	-1.62	-1.20	-.80
1958	-.18	1.46	.27	-2.05
1959	.94	.92	.17	.44
1960	1.32	.95	3.15	.63
1961	2.65	.07	-.62	1.97
1962	2.79	.17	-2.06	1.97
1963	.71	3.70	1.62	5.81
Sex:				
Bulls	.88	-	1.20	-
Steers	-.88	-	-1.20	-
Age of dam:				
of dam:				
2	-1.39	-.70	-.02	-1.36
3	-.80	.40	.49	-1.42
4	-.51	-1.10	.22	2.12
5	-.01	-1.04	-.48	.00
6	.04	1.67	-.32	1.94
7	.40	.35	.00	-1.26
8	-.01	2.02	-1.33	.60
9	2.38	-.25	.70	.76
10+	-.10	-1.35	.74	-1.38
Inbreeding:				
Dam	-.020	-.078	-.076	-.013
Calf	-.004	-.119	-.072	-.059

Table 9. Estimates of Constants for Weaning Weight

Effect	Old Line Males	Old Line Females	Outcross Line Males	Outcross Line Females
α	505	511	541	480
Year:				
1950	53	4	-3	22
1951	51	-8	14	18
1952	19	-33	-15	-16
1953	-24	-12	-35	-8
1954	-102	-36	-3	-36
1955	-46	-20	-25	-4
1956	-64	-50	-37	-4
1957	-36	6	-11	26
1958	-46	13	-21	-31
1959	24	26	28	-20
1960	16	14	38	-22
1961	78	42	1	48
1962	64	29	-11	41
1963	13	25	80	-14
Sex:				
Bulls	31	-	39	-
Steers	-31	-	-39	-
Age of dam:				
2	-40	-37	-14	-46
3	-19	-1	-20	-30
4	2	-3	-8	16
5	8	-1	-27	-12
6	24	10	11	36
7	-6	9	1	1
8	-2	44	-20	28
9	37	-7	29	29
10+	-4	-14	48	-22
Inbreeding:				
Dam	-.830	-.226	-.175	-.904
Calf	.772	-1.362	-2.241	-.866

IX. Project summary:

New Mexico Agricultural Experiment Station

Cattle Inventory - June 1965			
Breed	Hereford	Hereford	Hereford
Line	Old	Outcross	
Purebred or grade	Purebred	Purebred	Grade
Bulls (12 mo. or over)	16	2	
Cows (2 yr. or over)	40	21	94
Heifers (yearlings)	18	55	-
Calves - bulls	14	4	-
- steers	1	4	33
- heifers	8	5	33

Cow Production Data - 1964 calf crop			
Number cows bred to calve:			
As 2-yr.-olds	-	1	-
At 3 yr. and up	38	16	80
Number calves born from:			
2-yr.olds - alive	-	1	-
3-yr.-olds and up - alive	30	12	67
- dead	1	1	5
Number calves weaned	28	13	65
Percent calf crop[1] - born	81.6	82.3	90.0
- weaned	73.7	76.5	81.2

Preweaning Performance - 1964 calf crop			
Birth weight - bulls	79.1	74.6	
- heifers	70.8	69.6	
Weaning age - males	246	245	209
- heifers	246	250	210
Weaning weight - bulls	517	518	
- steers	479	438	358
- heifers	491	456	344
Adjusted weaning - bulls	518	524	
weight[2] - steers	479	434	355
- heifers	490	451	341
Weaning score:			
Conformation - bulls	6.50	7.00	
- steers	7.50	5.50	7.23
- heifers	7.54	6.75	7.43
Condition - bulls	11.42	11.50	
- steers	12.00	8.00	
- heifers	11.64	10.25	
Average inbreeding - bulls	.28	.24	
- steers	.28	.23	
- heifers	.30	.23	

[1] Born = $\frac{\text{Calves born}}{\text{Cows exposed}} \times 100$ Weaned = $\frac{\text{Calves weaned}}{\text{Cows exposed}} \times 100$

[2] Old and Outcross lines, 246 days; grade, 205 days.

New Mexico Agricultural Experiment Station

Postweaning Performance

Breed	Hereford	Hereford
Line	Old	Outcross
Sex	Bulls	Bulls
Method of feeding	Individual	Individual
Number on test	9	2
Average age on test	318	323
Initial weight	651	738
Days on test	140	140
Average daily gain	2.77	2.67
Feed efficiency:		
TDN/100 lbs. gain	424.8	481.0
Final weight	1039	1112
Average inbreeding	.31	.18

OREGON STATE UNIVERSITY

I. Station: Oregon Agricultural Experiment Station, Corvallis

II. Project title: Diallel crossing in beef cattle and its use in breed improvement

III. Personnel:

Experiment Station:
Ralph Bogart, Project Leader, Walter Kennick, A. T. Ralston, L. D. Calvin, Al Anglemier, Paul Humes, Prentiss Schilling, Frank Hoornbeek, W. A. Sawyer, Joe Wallace, James McArthur, and Bob Raleigh

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
J. S. Brinks, Investigations Leader

IV. and V. Nature and extent of work done this year:

Objectives:

1. Determine the genetic value of Hereford lines 1, 2, and 3 by making diallel matings to test for specific and general combining abilities, maternal effects, and sex linkage.

2. Assess heterotic effects by measurement of performance traits, carcass evaluations, blood and tissue chemical determinations, and physiological methods.

3. Continue the development of the Angus line.

4. Develop new Hereford lines from lines or line crosses of Oregon State and/or the U. S. Range Livestock Experiment Station.

Major results of the year:

The third diallel matings of the Hereford lines 1, 2, and 3 were made. The second crop of linecross calves was weaned from the mating of one year ago. There were 30 linecross calves and 13 inbred calves weaned in 1964.

The yearling linecross heifers born in 1963 were mated to an inbred Angus bull in 1964 to obtain calves to measure the calf producing ability of the linecross females.

The Angus line was continued as a two-sire line.

Certain cows in the herd that were problem breeders in the past were treated with hormones to see if increased conceptions in these animals could be obtained. They were first fed Repromix for 18 days to keep them out of heat and then some were given hormone injections if palpation indicated that therapy was needed.

The bulls from the 1963 calf crop were all slaughtered at 1000 pounds. At the time of slaughter, weights of testes, adrenals, thyroid glands, and pituitary glands were obtained. Also, live-dead stains were made on sperm from the head and tail of the epididymis of both testes on each bull to determine if there is an increase in fertility of the linecross bulls over the inbred bulls. At this time results have not been completed. Carcass data were obtained from each of these bulls which included yield of trimmed wholesale cuts, percent of lean, fat, and bone made from a one-rib section of the rib cut. Also, the meat was evaluated by a taste panel.

Blood analyses of amino acid, urea nitrogen, and creatinine were made on all animals at 450 and 750 pounds. On the bulls that were slaughtered, a third analysis was determined at the 1000-pound weight, also.

Blood enzyme work on the 1964 calf crop is being carried on in cooperation with Dr. Church at the present time.

Performance records were analyzed from the three Hereford and one Angus lines from 1951 to 1962. The analyses included the amount of selection practiced, the realized responses, levels of inbreeding and associated performance, and the heritability of the performance traits. Selection differentials for all performance traits were positive when the averages for both parents were considered. Selection differentials computed from the sire side of the matings were all positive and were higher than those on the dam side as a consequence of greater selection intensity through the sires. Automatic selection against inbreeding occurred on the sire side in conjunction with selection for increased performance. Due to the low selection intensity for females, selection was for increased inbreeding on the dam side of the matings. Inbreeding increased in all lines over a 12-year period. Performance increased early in the inbreeding program, then leveled off and subsequently declined. Score improved in all lines. Generally favorable response in the Angus line resulted from a lower initial performance, a broader genetic base, and more animals from which to select. Data from repeat matings showed that more variability in performance existed during the preweaning than in the postweaning period. Zero and low levels of inbreeding were associated with high preweaning performance and low postweaning performance. At higher stages of inbreeding, the reverse was true. Heritability estimates differentiated between the highly heritable traits, postweaning rate, and economy of gain, and the lowly and moderately heritable traits, respectively, preweaning gain and score.

A preliminary analysis was made on the results from the first diallel mating. Differences in general combining ability between lines were found for postweaning rate and economy of gain. The Lionheart line was the best general combiner, followed by the David and Prince lines. Specific combining ability differences in rate of gain favored crosses between the more rapidly gaining Lionheart and David lines. The Prince and David cross was the lowest performing cross among the specific crosses. The analyses of differences in economy of gain were similar to those for postweaning rate of gain, but there was also a significant difference in favor of linecross over inbred calves. This was probably due to the economy of gain contributed by the Prince line to the linecross calves. A highly significant association existed between postweaning rate and economy of gain with rate of gain accounting for 77 percent of the variation in economy of gain. Higher scores were given to Lionheart × Prince calves than calves resulting from crosses involving the lower scoring David line. Prince and David inbred calves contributed to the low score of all inbreds. Line of dam differences in score at 800 pounds were due to the less rapidly gaining David calves during the preweaning period, scoring lower at 800 pounds.

A disease, red nose, occurred in the 1964 calf crop at weaning time. With the cooperation of Dr. Kelsey of the Department of Veterinary Medicine and the splendid attention given the animals by Jerry Green, this difficulty was brought under control and the animals are now doing well.

In cooperation with Dean Frischknecht and Ray Novotny, 100 cows were given orally effective progestogen and 100 cows were given implants to prevent estrus for 18 to 21 days. These cows were owned by a commercial producer in Harney County. At the termination of the progestogen treatment, all cows were inseminated as they came in heat or on the third day regardless of whether heat was expressed. Those given the implants required surgical removal of the material which was not resorbed by the end of the 18th day.

In cooperation with John Landers and Kansas State University, data have been assembled on feed efficiency for more than 500 animals by 50-pound increments between 500 and 800 pounds body weight. Efficiency expressed as gain per unit of feed and gain per unit of feed over maintenance costs will be studied as weight of the animal changes. The data have been assembled so that line of breeding, sex, year, age of dam, rate of gain, and age of calf at 500 pounds can be studied to determine their effects on feed efficiency.

VI. Work planned for next year:

The final matings for completion of the diallel crossing will be made. It will be necessary to secure bulls to be used in the establishment of lines from the linecross material so they will be in breeding condition when needed the following year.

The Angus line will be continued as a two-sire line.

Physiological data on calves produced by the diallel matings will be gathered. Amino acid, urea nitrogen, and creatinine of the blood will be obtained on all calves at 450 pounds and 750 pounds and also on animals slaughtered at the time of slaughter.

Feed test all bulls and heifers and then carry the bulls on to 1000 pounds, at which time they will be slaughtered with the exception of those animals needed for breeding purposes. Carcass data are to be obtained and the data will include the yield of trimmed wholesale cuts, percent lean, bone, and fat of a selected cut, and evaluation by a taste panel. Also, weights of testes, adrenals, thyroid glands, and pituitaries will be obtained.

Make enzyme studies of liver tissue from the bulls produced in the diallel crossing to determine if inbred and linecross animals differ in enzyme activity.

Breed all heifers resulting from the diallel mating to the same inbred Angus bull as a means of obtaining calves to measure the calf producing abilities of these heifers.

Continue to gather data at the Eastern Oregon Station on calf producing ability of cows sired by bulls from the four Hereford lines. Summarize the data for analyses as rapidly as data are available.

A preliminary study on the carcass data from the bulls produced by the diallel matings in 1963 and 1964 will be made to compare inbreds with linecrosses to estimate general combining ability and to estimate specific combining ability.

VII. Publications:

Hoornbeek, Frank Kent 1964. Selection applied, response of traits, and combining ability of inbred lines of beef cattle. Ph. D. Thesis. Oregon State University. Corvallis.

Hunt, Lynn, and Ralph Bogart. 1964. Radiation damage to ova and to the uterus of the rabbit. Oregon Acad. Sci. Proc.

Hunt, Lynn, and Ralph Bogart. 1964. Radiation damage to ova and to the uterus of the rabbit. J. Anim. Sci. 23(3):849. (Abstr.)

Oregon Agricultural Experiment Station

Cattle Inventory - June 1965

Breed	Hereford	Hereford	Hereford	Hereford
Line	Lionheart	Prince	David	Lionheart × Prince
Purebred or grade		Purebred		
Bulls (12 mo. or over)	2	3	3	2
Cows (2 yr. or over)	23	24	23	6
Heifers (yearlings)	2	1	1	9
Calves - bulls	2	2	4	5
- heifers	3	1	1	5

Cow Production Data - 1964 calf crop

Number cows bred to calve:				
As 2-yr.-olds	3	2	0	
At 3 yrs. and up	21	21	23	
Number calves born from:				
2-yr.-olds - alive	2	2	0	
3-yr.-olds and up - alive	14	14	12	
- dead	1	1	0	
Number calves weaned	16	16	12	
Percent calf crop[1] - born	66.67	69.57	52.17	
- weaned	66.67	69.57	52.17	

Preweaning Performance - 1964 calf crop

Birth weight - bulls	79.25	77.11	76.00	
- heifers	70.88	66.00	68.60	
Weaning age - bulls	170.00	186.00	192.28	
- heifers	178.84	182.17	166.60	
Weaning weight - bulls	426.87	394.00	408.14	
- heifers	356.75	356.67	383.00	
Adjusted weaning - bulls	498.43	426.37	430.12	
weight[2] - heifers	398.57	393.10	455.47	
Weaning score:				
Conformation - bulls	11.43	10.83	11.40	
- heifers	11.40	11.39	11.76	
Condition - bulls	10.71	10.45	10.64	
- heifers	10.81	11.01	11.33	
Average inbreeding - bulls	.0828	.0864	.0455	
- heifers	.0408	.0246	.0419	

[1] Born $= \frac{\text{Number calves born alive}}{\text{Total number cows exposed}} \times 100$

Weaned $= \frac{\text{Number calves weaned}}{\text{Number cows bred}} \times 100$

[2] 205-day adjusted weight $= \frac{\text{Weaning weight - birth weight}}{\text{Age in days}} \times 205 + \text{birth weight}$

Oregon Agricultural Experiment Station

Cattle Inventory - June 1965				Total
Breed	Hereford	Hereford	Angus	
Line	Lionheart × David	Prince × David	Angus	
Purebred or grade			Purebred	
Bulls (12 mo. or over	2	2	4	18
Cows (2 yr. or over)	4	4	21	105
Heifers (yearlings)	4	2	3	22
Calves - bulls	8	4	6	31
- heifers	4	4	12	30

Cow Production Data - 1964 calf crop		
Number cows bred to calve:		
As 2-yr.-olds	4	9
At 3 yrs. and up	19	84
Number calves born from:		
2-yr.-olds - alive	4	8
3-yr.-olds and up - alive	17	57
- dead	0	2
Number calves weaned	21	65
Percent calf crop[1] - born	91.30	69.89
- weaned	91.30	69.89

Preweaning Performance - 1964 calf crop		
Birth weight - bulls	69.58	74.86
- heifers	62.17	67.16
Weaning age - bulls	179.33	181.44
- heifers	156.33	171.64
Weaning weight - bulls	424.83	414.33
- heifers	398.50	372.20
Adjusted weaning - bulls	475.69	458.42
weight[2] - heifers	503.21	431.49
Weaning score:		
Conformation - bulls	11.90	11.43
- heifers	12.47	11.72
Condition - bulls	10.74	10.64
- heifers	11.33	11.09
Average inbreeding - bulls	.0810	.0793
- heifers	.1077	.0532

[1] Born $= \frac{\text{Number calves born alive}}{\text{Total number cows exposed}} \times 100$

Weaned $= \frac{\text{Number calves weaned}}{\text{Number cows bred}} \times 100$

[2] 205-day adjusted weight $= \frac{\text{Weaning weight - birth weight}}{\text{Age in days}} \times 205 + \text{birth weight}$

Oregon Agricultural Experiment Station

Postweaning Performance - 1964 calf crop

Breed			Hereford			
Line	Lionheart		Prince		David	
Sex	Bull	Heifer	Bull	Heifer	Bull	Heifer
Method of feeding			Individual			
Number on test	3	2	5	1	1	1
Average age on test	193.7	179.5	213.8	184.0	216.0	143.0
Initial weight	466	413	453.8	430	457	407
Initial score -						
Condition	11.10	11.15	10.54	11.25	10.60	11.00
Conformation	11.75	12.25	11.05	10.75	11.25	11.63
Days on test	137.67	177.50	125.80	154.00	111.00	201.00
Average daily gain	2.61	1.85	2.89	2.08	3.12	1.70
Feed efficiency:						
TDN/100 lb. gain	447	599	385	499	390	623
Final weight	803.67	750.50	813.6	750.0	803.0	750.0
Final score:						
Condition	11.94	12.38	11.63	12.62	10.50	12.50
Conformation	12.49	12.90	11.55	12.50	9.63	12.00
Average inbreeding	.2207	.1633	.1556	.1475	.3186	.2097

Carcass - 1963 calf crop

Number	4	1	1
Carcass weight	571	580	527
Cutability - percent			
Percent lean	51.18	57.14	57.34
Carcass grade[1]	Low choice	Average good	High good

[1]USDA bull grades

Oregon Agricultural Experiment Station

Postweaning Performance - 1964 calf crop

Breed	Hereford					
Line	Lionheart × Prince		Lionheart × David		Prince × David	
Sex	Bull	Heifer	Bull	Heifer	Bull	Heifer
Method of feeding	Individual					
Number on test	5	9	5	4	5	2
Average age on test	196.6	220.6	201.4	187.8	218.0	207.0
Initial weight	455.4	408.0	456.6	403.3	461.0	400.5
Initial score:						
Condition	10.57	10.77	10.32	11.79	10.60	11.17
Conformation	10.98	11.30	11.02	11.33	11.40	11.29
Days on test	124.0	147.8	128.4	165.8	123.6	146.0
Average daily gain	2.89	2.37	2.79	2.15	2.88	2.40
Feed efficiency:						
TDN/100 lbs. gain	480	507	434	514	398	467
Final weight	812.2	756.8	810.0	760.3	806.4	751.0
Final score:						
Condition	12.30	12.18	11.27	12.30	11.45	11.75
Conformation	12.37	12.11	11.21	12.47	11.56	11.81
Average inbreeding	0	0	0	0	0	0

Carcass Data - 1963 calf crop			
Number	6	9	7
Carcass weight	566	562	554
Cutability-percent lean	52.27	51.99	51.78
Carcass grade[1]	Low choice	Low choice	High good

[1]USDA bull grade

Oregon Agricultural Experiment Station			
Postweaning Performance - 1964 calf crop			Total
Breed	Angus		
Sex	Bulls	Heifers	Bulls and heifers
Method of feeding		Individual	
Number on test	12	6	61
Average age on test	195.6	161.8	196.2
Initial weight	463.3	406.3	438.3
Initial score:			
Condition	10.74	11.33	11.43
Conformation	11.90	12.47	11.72
Fays on test	130.4	192.0	143.3
Average daily gain	2.68	1.85	2.52
Feed efficiency:			
TDN/100 lbs. gain	446	-	463
Final weight	809.5	755.7	775.0
Final score:			
Condition	11.79	11.64	11.85
Conformation	12.59	12.67	12.17
Average inbreeding	.0810	.1077	.0686

Carcass Data - 1963 calf crop			
Number	2		30
Carcass weight	578		563
Cutability-percent lean	47.35		51.93
Carcass grade[1]	High choice		Low choice

[1]USDA bull grades

UTAH STATE UNIVERSITY

i. Station: Utah Agricultural Experiment Station, Logan

II. Project title: The development of breeding techniques and selection criteria for improvement of economically important characteristics in Hereford and Shorthorn cattle

III. Personnel:

Experiment Station:
J. A. Bennett, Project Leader, Junior Nyman, and
William J. Nay, Jr.

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
J. S. Brinks, Investigations Leader

IV. Nature and extent of work done this year:

Calves that were straightline and crossline from the Colorado Brae Arden bulls and from the Montana Havre Line II bulls along with straightlines were produced in the Hereford line. Cows in the mating groups had been balanced for inbreeding level and stratified according to previous weaning weight of calves. A detailed statistical analysis of the performance of the calves is underway but not yet completed. However, the averages show Brae Arden calves to be heavier at birth than the straightline calves. Calves from one of the Montana bulls also were heavier at birth but the calves from the other Montana bull averaged a little lighter than the straightline calves. In average daily gain from birth to weaning, the calves from both Brae Arden bulls averaged higher than the calves from the straightline bulls, and one of the Montana bull's calves averaged higher while the other one was actually slightly lower. There is a strong possibility that some of these differences will prove to be significant.

Individual feeding tests have just recently been completed with 23 bulls. The crossline bulls showed no advantage in postweaning feeding period over the straightline bulls. There is very little difference in the average of the bulls from the various groups. Statistical analysis has not yet been completed on these groups.

A herd of dwarf carrier cows has been maintained and another yearling bull was mated with this group. No dwarf calves were produced again this year from such matings. Five yearling heifers were also mated to a dwarf bull for the purpose of producing replacement carrier test cows. It is felt that there would be an advantage in raising the carrier cow replacements rather than buying them from various herds wherever they can be located.

During the past year further work was done with the Model 12 Sonoray testing device in determining its usefulness for measuring fat thickness. This machine has worked without giving any trouble whatever and it appears that it gives a very reliable measurement of the thickness of the outside fat. Correlation values of some 0.75 have been attained on the total steers that have been tested including those where the technique was being developed. It is felt that a higher correlation than this can now be obtained. As yet, the machine has not been tested to determine its value for measuring thickness of muscle or estimating loin eye area.

Construction of new facilities for the beef cattle has proceeded throughout the year. These facilities are located on a new farm approximately six miles from the present University campus. By October 1965 it is expected that the sheds will be completed for the breeding herd and for individual feeding of test bulls. The individual feeding unit is designed to have each bull in an individual pen and it is felt that it will be an improvement over the present facilities.

Matings last year were such as to provide crossline calves and straightline calves for comparison again this year. These involved using one Colorado Brae Arden bull and the better performing of the two Montana bulls. These calves are now on the ground. Matings this year are within-line matings designed to propagate the existing lines.

V. Summary of progress and conclusions to date:

The developing of lines of Hereford and Shorthorn cattle is moving ahead according to plan. Production in the lines is very satisfactory and it appears that the use of a mild inbreeding system accompanied by selection on the basis of performance is a promising method for cattle improvement. It is felt further that the frequency for the dwarf gene has been materially reduced in the herd through the testing of young bulls prior to use in the herd on 15 to 16 carrier cows.

Information concerning methods of estimating the amount of fat in live animals has been tested and several have shown promise. Tritium and N-acetyl-4 amino acid antipyrine have both shown to be quite effective for this. Tritium is probably the more accurate of the two. Methods of using both of these, however, are very technical and require considerable equipment and more practical methods would be highly desirable. The Sonoray machine, the Branson Model 12 in particular, which has been tested at this station, is very promising as a method for estimating thickness of outside fat in live cattle. The machine appears to be accurate and the readings require very little time and are easily made. It also has been shown that direct measurements of outside fat by use of a needle as a probe give an accurate estimation. This technique requires some development before an operator is efficient, and it does take more time than the Sonoray, but it is equally accurate.

VI. Application of findings:

The findings of this project indicate that a system of mild inbreeding accompanied by selection on the basis of performance is a safe and rather effective method for improvement of beef cattle and is a method that could be practiced by many purebred livestock operators. Findings from this project in regard to the development of testing procedures have demonstrated to the cattlemen of the state how performance testing can be done and its value, and have been a means of getting cattlemen interested in measuring performance in cattle. The program has now grown and annually some 1,000 head of cattle are put through performance test on the farms.

This project also has developed methods by which the amount of body fat can be estimated. These methods can be of value to research workers but are not practical for field application. Estimation of outside fat, however, can be done much more quickly and has greater possibilities of field application.

VII. Work planned for the future:

1. Continue developing lines of Hereford and Shorthorn cattle through a system of mild inbreeding accompanied by selection

2. Measure performance of crossline cattle as compared to straightline cattle. These comparisons made again this year and detailed statistical analyses will be made of the data that have been already collected.

3. Collect and analyze information on carcass qualities of the lines of cattle

4. Continue to analyze data that have been collected to obtain more exact information on performance and to develop more useful adjustment factors to enable more accurate comparisons

VIII. Project summary:

Cattle Inventory - June 1965					Total
Breed	Hereford	Hereford	Shorthorn	Hereford	
Line	I	II	I	Dwarf	
Purebred or grade		Purebred		8 purebred 4 grade	
Bulls (12 mo. or over)	16	4	5	1	26
Cows (2 yr. or over)	51	21	37	12	121
Heifers (yearlings)	11	4	6	2	23
Calves - bulls	20	11	17	9	57
- steers	4	2	2	0	8
- heifers	32	3	14	3	52

Utah Agricultural Experiment Station

Cow Production Data - 1964 calf crop

Breed Line Station	Utah Hereford I Straight Panguitch	Colorado Hereford I Crossline Panguitch	Montana Hereford I Crossline Panguitch	Utah Hereford II Straight Logan	Utah Shorthorn I Straight Logan	Utah Hereford II Dwarf Carrier Logan	Total
Number cows bred to calve:							
As 2-yr.olds	6	9	0	3	6	0	24
At 3-yrs. and up	16	15	17	11	28	13	100
Number calves born from:							
2-yr.olds - Alive	3	9	0	2	6	0	20
- dead	3	0	0	1	0	0	4
3-yr.-olds and up - alive	14	15	17	11	24	13	94
- dead	2	1	0	0	4	0	7
Number calves weaned	17	21	14	12	28	12	111
Percent calf crop - weaned[1]	77.3	87.5	82.3	85.7	82.4	92.3	89.5

Preweaning Performance - 1964 calf crop							
Birth weight - bulls	73	80	76	70	71	70	73
- heifers	74	78	69	64	69	63	71
Weaning age - bulls	186	192	182	214	222	225	205
- heifers	187	192	203	228	201	208	199
Weaning weight - bulls	410	450	430	421	428	413	428
- heifers	390	392	422	413	378	368	390
Adjusted weaning - bulls	440	490	468	413	404	382	428
weight[2] - heifers	432	465	422	377	349	365	392
Weaning score:							
Conformation - bulls	1.8	1.7	2.1	1.9	2.0	1.9	1.9
- heifers	2.1	1.8	2.0	1.9	2.0	2.4	2.0
Condition - bulls	2.4	2.7	3.0	2.4	2.6	1.9	2.5
- heifers	2.9	2.9	2.7	2.5	2.6	2.4	2.7

[1]Based on number of calves at weaning

[2]Adjusted to mature dam, 205 days of age

Utah State Agricultural Experiment Station

Postweaning Performance - 1964 calf crop

Breed	Utah Hereford	Colorado Hereford	Montana Hereford	Utah Hereford	Utah Shorthorn	Total
Line	I	I	I	II	I	
	Straight	Crossline	Crossline	Straight	Straight	
Station	Panguitch	Panguitch	Panguitch	Logan	Logan	
Sex	Bulls	Bulls	Bulls	Bulls	Bulls	
Method of feeding	Individual - feedlot					
Number on test	4	8	4	2	5	23
Average age on test	257	259	259	225	274	259
Initial weight	472	557	514	452	553	525
Initial score:						
Condition	1.6	1.6	1.9	1.5	1.9	1.7
Conformation	2.6	2.6	2.7	1.9	2.4	2.5
Days on test	121	126	121	112	112	120
Average daily gain	2.48	2.38	2.53	2.71	2.51	2.48
Final weight	766	846	820	750	850	815
Final score:						
Condition	2.0	1.9	2.0	2.0	1.8	1.9
Conformation	2.3	2.2	2.4	2.4	1.9	2.2

WASHINGTON STATE UNIVERSITY

I. Station: Washington Agricultural Experiment Station, Pullman

II. Project title: Comparison of breeding systems for improvement of beef cattle

III. Personnel:

Experiment Station:
C. C. O'Mary, Project Leader; Douglas Bennett, Herdsman; Gary Smith, Meats Specialist; Hal Sellers and S. K. Shah, Graduate students

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
J. S. Brinks, Investigations Leader

IV. Nature and extent of work done this year:

Data collected include birth weights, weaning weight, rate and efficiency of gain on performance test, and carcass data. The performance of the two herd sires was compared on the basis of their progeny. Since the cows were randomized by age group the cow groups were comparable. Progeny sired by bull TE6 were superior to those sired by 100 in every respect except conformation score.

Weekly weight gains and feed consumption were kept on the animals which were on performance test.

A winter ration consisting of peavine silage plus alfalfa hay was compared to a ration consisting of peavine silage alone. The cows were randomly assigned within breeding groups to the two treatment groups. Weight changes in the cows and birth weights of their calves were used as indicators of ration effects.

Two groups of bulls were fed at different levels to determine the effect of fatness on semen characteristics on the bulls' libido.

The breeding program with respect to the overall plan continued on schedule with respect to breeding groups A, B, and C. Three sires were used in 1964. These same three also are being used in 1965.

V. Summary of progress and conclusions to date:

The first information on individual animals from birth weight through carcass data has been collected on 12 bulls. Sire differences have been noted on the various traits studied. While stockmen may prefer to match cows and bulls to secure "nicking" effects, randomizing cows to bulls permits direct comparisons.

The use of different rations for cows confound some of the results on effects on offspring because of unpredictable sex ratios of calves within the sub-groups.

Bulls on a high fattening ration produced about the same volume of semen and same sperm concentration as bulls on a normal ration. However, motility of sperm showed a significant negative regression with time in the high-fed group, but not in the normal-fed group.

VI. Application of findings:

From a research point of view, superimposing management studies on a breeding program where selection is to be made, extreme care must be taken to avoid confounding of results or complicated interactions and unequal sub-class numbers.

It is obvious that bulls can be compared on the basis of their progeny's performance where the progeny have been tested under the same conditions.

VII. Work planned for the future:

The barn in which animals have been performance tested burned in 1964. A new barn is being planned. Performance testing of both bulls and heifers from groups A, B, and C will be continued by individual feeding.

Cooperation with the Colorado station on blood and meat sample analysis will be continued.

The data on the animals from dams on different winter rations will be further studied to determine carry-over effects since ration of dam did affect birth weight of calf.

Analysis of the feed efficiency data will be continued.

The data for determining various correction factors are still being checked and upon completion of this will be placed on IBM cards and an analysis can be made.

VIII. Publications and manuscripts:

Bennett, Douglas D, M. H. Ehlers, and C. C. O'Mary. Effect of obesity on reproductive traits of beef bulls. J. Anim. Sci. 24(3): 914. Abstr. 282.

Sellers, Hal, Douglas D. Bennett, and C. C. O'Mary. Silage vs. silage plus hay for wintering beef cows. J. Anim. Sci. 24(3):856. Abstr. 46.

Washington Agricultural Experiment Station

Cattle Inventory - June 1964					Total
Breed	Angus	Angus	Angus	Angus	Angus
Line (Sire)	TE6	100	781	762	Eileenmere
Purebred or grade			Purebred		
Bulls (12 mo. or over)					10
Cows (2 yr. or over)					70
Heifers (yearlings)					10
Calves - bulls					29
- heifers					32

Cow Production Data - 1965 calf crop	Total
Number cows bred to calve:	
As 2-yr.-olds	12
At 3 yr. and up	60
Number calves born from:	
2-yr.-olds - alive	11
- dead	0
3-yr.-olds and up - alive	54
- dead	2
Number calves weaned	61
Percent calf crop[1] - born	91.7
- weaned	84.7

Preweaning Performance - 1964 calf crop				
Birth weight - bulls	65.9	57.8		
- heifers	56.7	56.1		
Weaning age - bulls	227	232	164	162
- heifers	232	233	169	191
Weaning weight - bulls	495	470	340	350
- heifers	452	415	332	359
Adjusted weaning - bulls	408	373		
weight[2] - heifers	360	328		

[1] $\frac{\text{Total calves born}}{\text{Number cows bred}} \times 100$

[2] $\frac{\text{Weaning weight - birth weight}}{\text{Age}} \times 180 + \text{birth weight}$

Washington Agricultural Experiment Station

Postweaning Performance - 1964 calf crop

Breed	Angus	Angus	Angus	Angus	Angus	Angus	Angus	Angus	Angus	Angus
Line (Sire)	TE6	TE6	100	100	Eileenmere	781	781	762	762	Eileenmere
Sex	Bulls	Heifers	Bulls	Heifers		Bulls	Heifers	Bulls	Heifers	
Method of feeding					Individual					
Number on test	13	10	8	17	48	2	4	31	1	10
Average age on test	252	257	257	258	265	189	194	187	216	193
Initial weight	578	507	533	457	513	400	397	413	406	403
Days on test	210	199	210	203	205	210	203	210	203	206
Average daily gain	2.28	1.53	1.84	1.36	1.72	2.00	1.47	2.24	1.22	1.78
Feed efficiency:										
Lbs.feed/100 lbs.gain	791	895	844	915	865	692	755	656	912	728
Final weight	1094	847	959	755	900	867	726	924	674	808
Final score:										
Conformation	87.4	89.6	88.2	88.4	88.3	88.0	89.0	87.7	88.0	88.3

Carcass Data			
Bulls:			
Number	6	5	1
Fat thickness - 12th rib	.24	.31	.33
Rib eye area - sq.in.	13.21	12.23	10.32
Carcass weight	619	537	513
Cutability - percent	53.11	52.47	51.84
Carcass grade	5 good 1 choice	3 good 1 low good	Good (bull)[1]

[1]Graded as steer but actually was bull

UNIVERSITY OF WYOMING

I. Station: Wyoming Agricultural Experiment Station, Laramie, and Gillette Substation, Gillette

II. Project title: Criteria for improving effectiveness of selection in beef cattle. W.S. 655.

III. Personnel:

Experiment Station:
G. E. Nelms, Project Leader, R. A. Field, and C. O. Schoonover, Animal Science Division
W. W. Ellis, Biochemistry Division
Leon Paules, Substation Division
Brinton Swift, Veterinary Science Division

U. S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado
J. S. Brinks, Investigations Leader

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

The effect of sex, age, and marbling on palatability of beef has been summarized. Longissimus dorsi roasts from the 12th rib were evaluated by the W-B shear for tenderness and by a trained panel for tenderness, juiciness, and flavor. The roasts were obtained from Hereford, Angus, and Shorthorn cattle varying in age from 300 to 700 days and in marbling from traces to moderate amounts. No differences were found between bulls and steers up to 500 days of age. Bulls were significantly tougher at ages above 500 days.

The steer carcasses exhibited more flavor and juiciness after 600 days of age. When marbling was held constant, younger animals were more tender in the case of bulls. Age was not important in steers with marbling held constant. Simple correlations between age and tenderness indicated that bulls became less tender with age and steers became more tender with age.

Hematocrit values, total serum protein, percent serum albumin and globulins have been determined on 265 yearling bulls. Line differences were found in all variables except beta globulin, indicating possible genetic differences. However, none of the traits were related to performance up to yearling age.

A bull was sold to Arizona as part of the Regional Genetic-Environment Interaction Project.

Table I. Unadjusted Means, Standard Deviations, and Differences in Traits Studied by Age Groups

Characters studied	Mean	S.D.	Mean	S.D.	Difference between means (♂ and ♀ - ♂)
	13 steers and heifers		55 bulls		
Age (300-399 days)[1]	371.4	21.3	366.7	19.1	4.70
Carcass wt. (kg.)	139.8	28.1	175.3	27.2	-35.5 **
Marbling[2]	2.9	1.12	3.1	1.01	-.20
W-B shear (kg.)	3.12	1.20	2.81	.84	.31
Tenderness	5.38	1.57	5.28	1.19	.10
Flavor	5.76	.61	5.82	.54	-.07
Juiciness	5.88	.77	5.56	.64	.32
	15 steers and heifers		24 bulls		
Age (400-499 days)[1]	434.7	25.8	450.7	29.8	-16.0
Carcass wt. (kg.)	177.8	46.3	244.3	30.1	-66.5**
Marbling[2]	4.1	1.19	4.3	.92	-.20
W-B shear (kg.)	3.01	1.22	3.60	.81	-.59
Tenderness	5.71	1.52	4.99	1.26	.72
Flavor	5.97	.50	5.82	.46	.16
Juiciness	5.86	.58	5.68	.77	.18
	26 steers and heifers		37 bulls		
Age (500-599 days)[1]	536.0	32.4	564.1	29.2	-28.0**
Carcass wt. (kg.)	255.3	37.9	296.1	24.2	-40.8**
Marbling[2]	4.9	.98	3.9	1.17	1.0**
W-B shear (kg.)	2.45	.81	3.31	.94	-.86**
Tenderness	6.29	1.23	4.87	1.22	1.42**
Flavor	6.16	.58	5.89	.55	.27
Juiciness	5.88	.69	5.61	.68	.27
	30 steers and heifers		18 bulls		
Age (600-699 days)[1]	645.4	25.7	635.2	30.8	10.2
Carcass st. (kg.)	277.4	33.5	318.6	27.7	-41.2**
Marbling[2]	5.0	1.08	3.6	1.15	1.4**
W-B shear (kg.)	2.72	.99	3.36	.92	-.64**
Tenderness	6.36	1.03	4.73	1.34	1.63**
Flavor	6.29	.70	5.58	.63	.71**
Juiciness	6.21	.58	5.58	.62	.62**

[1]Numbers in parenthesis are range in days
[2]Numerical values were substituted for scores as follows: 2, traces; 3, slight; 4, small; 5, modest; 6, moderate
**

VI. Work planned for the future:

The project is subject to revision in 1966. The proposed changes will be submitted at the 1965 meeting in Fort Collins, Colorado. No major changes are contemplated. Essentially, it will involve eliminating the Shorthorn herd and enlarging the existing lines of Herefords. A line based upon carcass desirability will be initiated.

A cooperative herd will be included as part of the Regional Genetic-Environment Interaction Project.

VII. Publications:

Anderson, L. R. 1965. Serum protein and hematocrit values as correlated with growth in yearling beef bulls. M. S. Thesis. University of Wyoming. Laramie.

Field, R. A., G. E. Nelms, and C. O. Schoonover. 1965. Effects of age, marbling, and sex on palatability of beef. J. Anim. Sci. 24(3):862. Abstr. 68.

Herold, Alan, and G. E. Nelms. 1964. Relationship of striated muscle nuclei numbers and growth in beef cattle. Amer. Soc. Anim. Sci. West. Sect. Proc. 15:III.

Nelms, G. E., and M. P. Botkin. 1965. Controlling estrous cycles in sheep and cattle. Wyo. Agr. Expt. Sta. B. (In press.)

Nolan, J. C., R. A. Field, C. O. Schoonover, and G. E. Nelms. 1965. Relationships between carcass and 9-10-11th rib characteristics of bulls. Amer. Soc. Anim. Sci. West. Sect. Proc. 16:XXIX.

VIII. Project summary:

Wyoming Agricultural Experiment Station

Cattle Inventory - June 1965					Total
Breed	Hereford	Hereford	Angus	Shorthorn	
Line	Gillette	Laramie	Laramie	Laramie	
Purebred or grade		Purebred			
Bulls (12 mo. or over)	3	7	4	4	18
Cows (2 yr. or over)	32	48	36	23	139
Heifers (yearlings)	8	11	8	2	29
Calves - bulls	14	29	21	11	75
- heifers	17	18	15	11	61

Cow Production Data - 1964 calf crop					
Number cows bred to calve:					
As 2-yr.-olds	8	10	8	0	16
At 3 yr. and up	30	46	30	26	132
Number calves born from:					
2-yr.-olds - alive	6	8	8	0	22
- dead	1	1	0	0	2
3 yr. and up - alive	27	41	26	20	114
- dead	3	2	2	4	11
Number calves weaned	33	46	31	19	129
Percent calf crop[1] - born	97	88	95	92	92
- weaned	87	82	82	73	87

Preweaning Performance - 1964 calf crop				
Birth weight - bulls	76	71	56	75
- heifers	71	67	51	63
Weaning age - bulls	189	192	200	202
- heifers	193	199	202	225
Weaning weight - bulls	401	374	409	444
- heifers	376	366	374	435
Average inbreeding:				
- bulls	15.9	0	Not calculated	
- heifers	15.8	0	"	"

Postweaning Performance - 1964 calf crop								
Breed	Hereford		Hereford		Angus		Shorthorn	
Line	Gillette		Laramie		Laramie		Laramie	
Sex	♂	♀	♂	♀	♂	♀	♂	♀
Method of feeding				Group - feedlot				
Number on test	14	13	16	16	13	11	8	2
Average age on test	197	201	192	199	200	202	202	225
Initial weight	410	358	374	366	409	374	444	435
Days on test	168	168	168	168	168	168	168	168
Average daily gain	2.32	1.58	2.25	1.36	2.10	1.35	2.30	1.34
Final weight	801	625	753	596	763	601	833	660
Average inbreeding	15.9	15.8	0	0		Not calculated		

W-1 Technical Committee Meeting
September 6 and 7, 1965

W. C. Rollins, Chairman

Project Reports

Dr. Roubicek discussed the Arizona project involving the use of Hereford bulls from ten lines developed at various stations in the region. He pointed out that the San Carlos personnel would like bulls three years of age or older, in good condition, physically sound (especially feet and legs) and be of an acceptable color patter. The bulls will be picked up at the station about the middle of October.

The summary sheet on bulls used during the 1965 breeding season was distributed (see following page).

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Dr. Rollins discussed the California crossbreeding project dealing with the three British breeds. In phase 1 at Davis, the first-cross A^xH, A^xS, and H^xS offspring are being produced. The third calf crop is about to be dropped. Straightbred and crossbred heifers from these matings will go to the Foothills station and will be mated to bulls of the three British breeds. The first calf crop heifers will be bred soon to an Angus bull. Present facilities made AI impossible.

In the Angus-Hereford comparisons (AH + HA) - (HH + AA), the following measures of hybrid vigor were obtained:

Birth weight	0.0 ± 2.5	pounds
Weaning weight	15 ± 9	pounds
Weaning grade	.2 ± .3	units (3 units represent the difference between Choice and Good)

By using AI, one can obtain gestation lengths. There was no evidence of hybrid vigor in gestation length, but the difference between Hereford and Angus cows (HH - AA) was 6 ± 3 days. There was a 14-pound difference in birth weight between Hereford and Angus dams. When birth weight was included as a covariant in the gestation length model, the difference in gestation length was 1 ± 3 days.

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Dr. Stonaker discussed the Colorado work dealing with fertility as related to DNA content of individual sperm cells. Dr. Salisbury of Illinois visited the Fort Lewis station last spring and collected slides on 80 yearling bulls including inbreds, linecrosses, crossbreds, and a few Holsteins. They have been making DNA counts on individual sperm cells to determine whether the problem of fertility in inbred bulls is associated with inbreeding. Leuchtenberger has found in man that infertile males tend to be highly variable in chromosome count of sperm cells as related to DNA. Fechheimer of Ohio is doing a simultaneous study of chromosome counts from leucocytes.

Summary of Individual Data on Regional Bulls Used at Arizona During the 1965 Breeding Season

Name and Origin of bull	Tattoo and Registration number	Birth weight Act.	Birth weight Dev.	Weaning weight Act.	Weaning weight Dev.	Adjusted weaning weight Act.	Adjusted weaning weight Dev.	Daily gain on test Act.	Daily gain on test Dev.	Feed efficiency Act.	Feed efficiency Dev.	Days on test Act.	Days on test Dev.	Final weight off test Act.	Final weight off test Dev.	Age off test Act.	Age off test Dev.
MSC Clay's Supreme 33	114																
Bozeman, Montana	11683317	80	3	545	95	442	74	2.40	0.20	6.82[1]	-.08	140	0	939	168	391	2
L4 Mischief 100	9250																
Miles City, Montana	11008357	91	12	417	36	395	16	2.91	.27	24.56[2]	1.73	196	0	1006	54	396	4
L14 Mixer 77	1423																
Miles City, Montana	11938061	85	6	464	66	460	72	2.74	.17	22.04[2]	.44	196	0	1013	61	387	-5
Marshall Brigadier	100																
New Mexico	12552263	88	6	652	98			3.29	.51	379[3]	-46	140	0	1107	68	444	-14
USU Advance Lad 0119	0119																
Utah	13012010	90	6	460	27	482	31	2.84	.26	6.50[1]	-.26	126	0	927	17	414	7
Reno E 307	722																
Reno, Nevada	12736479			495	9			1.81	.12	19.80[4]	1.00	140	0	748	26	384	-7
KC E 311	K-406																
Knoll Creek, Nevada	12736497			460	21			1.21	.10	17.50[4]	1.30	140	0	630	35	405	15
Royal 0006	0006																
Colorado	11306929			435	-34	515	16	2.85	0	6.18[1]	-.29	140	0	836	-37	416	8
Brae Arden 9068	9068																
Colorado	10875767			485	114	599	64	2.81	.23	6.25[1]	-.31	140	0	874	50	399	5
Gillette Arden 71	71																
Wyoming	12022300	79	2	457	53	413	5	2.41	.20	Group fed		168	0	860	74	371	6

[1]Feed/lb. gain - lower value is superior
[2]Lb. gain/cwt. TDN - higher value is superior
[3]TDN/cwt. gain - lower value is superior
[4]Gain/cwt. feed - higher value is superior

All bulls were used at the Arizona location. Satisfactory semen for freezing was obtained from bulls (tattoo numbers) 114, 9250, 722, K-406, 0006, and 71. Semen from these bulls was used in Wyoming, Oregon, and two locations in Hawaii.

The work dealing with the kinds and amounts of various lipids in blood and in fat and lean tissues was discussed and reference made to the annual report.

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Professor Flower discussed the Montana project at Havre and Bozeman. The Havre station has experienced a little anaplasmosis problem in bringing back station bulls from industry herds. These comparisons have been discontinued for the present. Some cattle in the Havre Line I and its linecrosses have shown a stiff front leg and shoulder condition. This is not founder.

The feedlot cattle at Bozeman were self fed a pelleted (1/2") concentrate ration this year and they averaged approximately 0.5 pound greater gain than hand fed cattle in previous years. This is the same ration that is being used at the IPR testing stations.

The topcross tests using Angus bulls in cooperators' herds are being continued.

Donald Anderson discussed the inbreeding computer program that has been developed and used to calculate the inbreeding coefficients on the Havre lines. The following description was distributed:

INBREEDING AND RELATIONSHIP COEFFICIENT PROGRAM

This program was written by Allen T. Yates, a student at Montana State University. The program is written for an IBM 1620 II, card input and output, with disk storage. The disk storage is necessary for storing the large matrix that will be used to figure the inbreeding of the animals.

The program is capable of figuring Wright's numerator relationship, thus giving the inbreeding of all the animals in a line. It will also give each relationship to every other animal in the matrix just as is accomplished by the use of a covariance chart. The program also can give the inbreeding of sample matings. A sample mating is any mating of animals which did not produce any offspring. The sample matings are not added to the matrix and can be used on any animal as long as the sire and dam are in the matrix.

The animals have to be numbered consecutively starting with the oldest animal as number one in order for the program to work. Each animal then needs a mating card that includes the sire and dam. These cards have to be fed into the computer in consecutive order starting with number one. The computer computes the inbreeding of the animal added, adds the animal to the matrix, and a card is punched with the following information:

Calf	- Dam	- Sire	- Related to	- Relationship	- I.D.	- F_x Mating
443	360	334	443	1.1362	63270	

When the matrix is large, i.e., 100-125 animals, the program will run slow, so the animals not needed should be deleted from the matrix. A delete card is given to the computer for each animal that is not needed in the matrix. The computer will then compress the size of the matrix to the number of animals left in it. It is very important for a fast running program to keep the matrix size as small as possible. The average computer time if the matrix is kept as small as possible is one to two minutes per animal in lines that have twenty to forty matings per year. If the lines are larger than this it will take much more computer time.

This program has been used on the three inbred lines at the North Montana Branch Station and has proved to be satisfactory for computing inbreeding in these lines. For further information about the program including the write-up, FORTRAN source decks, a sample problem and its output, and the object deck,contact the Computing Center, Montana State University, Bozeman, Montana.

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Dr. Bennett discussed the Utah work involving the development of lines through selection and mild inbreeding. Dwarfism has been pretty well eliminated, although a test herd is maintained for testing one yearling bull each year. The Utah Line I, located at Panguitch, has 50-plus females plus heifers that will be added. Inbreeding is increasing in the Shorthorn line, which has 30 breeding cows,each year. Inbreeding in the lines is variable, ranging from 3 to 29 percent.

Brae Arden bulls from Colorado, and Havre Line II bulls from Montana, are being used to produce linecross offspring along with straightline offspring. Two bulls in each subgroup were used the first year. One of the Montana bulls died and this year one bull in each subgroup was mated to 16 cows each. Following are the data on the first calf crop:

Line of sire	Adjusted Weaning Weight Males	Females	ADG Bulls
Utah	440	432	2.48
Colorado (2-year-old)	479	411	
Colorado 4	530	483	
Colorado average	490	465	2.38
Montana 749	523	431	
Montana 673	427	417	
Montana average	468	422	2.53

In the postweaning gain test, 1 pound of long hay was fed twice a day along with a pelleted ration. Both self feeding and hand feeding methods were used, and those on the self feeding regime gained from 0.33 to 0.50 pound more per day.

Work is continuing with the Sonoray Model 12 in measuring outside fat. Work on the probing technique has slowed down since there was almost perfect agreement between the probe and the Sonoray, which is faster.

Very little sire differences were found in the cooking tests. Cooking at 225 degrees yields more tenderness than at 325 degrees when both are brought to 165 degrees internal temperature.

A new performance testing shed is under construction.

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Dr. Pahnish described the work at the U. S. Range Livestock Experiment Station. The last crop of calves in phase 1 of the crossbreeding experiment were dropped this year. A summary of the first two years' data indicate that crossbred steers exceeded the average of the straightbred by 5 to 10 percent in growth traits. There was no consistent evidence of hybrid vigor for dressing percent, carcass grade, fat thickness, or rib eye area. In the females, there is no clearcut evidence of hybrid vigor for growth traits.

Phase 1 of the linecrossing project, which involves the crossing of five lines, parallels phase 1 of the crossbreeding study. A three-year summary indicates that there is evidence of hybrid vigor in growth traits. This effect is as pronounced in females as in males.

The genetic-environmental interaction study between the Miles City and Brooksville, Florida stations was discussed. This spring at Miles City the Brooksville cows weighed 961 pounds, whereas the Miles City cows weighed 1136 pounds. There have been no large differences in conception rate between the two groups. During the last year's severe winter, 34 percent of the Florida cows required special attention compared to 7 percent for the Miles City Line 1 cows. The Miles City heifers produced in 1963 and 1964 were 40 to 45 pounds heavier at weaning time, and gained faster until 18 months of age. Growth data from the Brooksville station indicate that the Florida calves are heavier at weaning and maintain this advantage until 12 months of age. At 18 months of age the difference in weights of the two groups is quite small.

Semen from five Line 1 bulls which are about one-half generation apart was used this year on grade Hereford cows as a check on genetic progress.

A Sonoray Model 12 was obtained during the past year and techniques for measuring fat thickness are being worked out.

A feed mill was installed this year which will save on labor requirements.

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Project Revisions:

Montana

Professor Flower distributed a proposed revision of the Montana project and stated it was tentative since the new Department Chairman had not yet been selected.

The proposal called for the work at Havre to remain nearly the same, but with some changes in the Bozeman work. Discussion followed on the use of sires in AI studs in comparison with closed herds. Professor Flower stated he would like to have suggestions sent to him.

Dr. Bogart moved that action be deferred in view of the fact that it is a tentative revision.

Dr. Bennett seconded the motion. Motion carried.

Wyoming

Dr. Nelms discussed the Wyoming revision that had been distributed earlier. The Shorthorn herd at Laramie will be discarded and numbers increased in the Hereford line. Two lines of Herefords and one line of Angus will be established with each line consisting of approximately 35 cows. One Hereford line will be selected for growth, one for carcass desirability, and the Angus line will be selected on growth and carcass desirability.

The study at the Gillette substation will continue as in past procedures.

It was suggested that a study on the use of repeat matings and stored semen for measuring genetic progress be included as an additional objective.

Dr. Bogart moved that the project be approved subject to the addition of this objective.

Dr. Pahnish seconded the motion. Motion carried.

BUSINESS MEETING

Chairman Rollins called the meeting to order at 1:00 P.M., September 7, 1965.

Dr. Rollins:

We were charged with establishing three special committees--

Committee on the Use of Trust Funds
Committee on Objectives and Wording of Regional Project
Committee on Regional Bulletins

We will have the report of the Committee on Use of Trust Funds.

Dr. Cobb (Chairman):

We circulated a letter asking for suggestions on the use of trust funds. This has been brought up from year to year by Dr. Wheeler--if there is a project that would benefit the region we should apply for money from the regional research trust fund to support such a project. With this in mind we asked for your suggestions. The project would have to fall within the objectives of the regional project.

(Dr. Cobb read from the Cooperative State Research Service manual the portion which listed the possible uses of these funds and how they are handled.)

The following proposals were suggested by members of the committee:

1. Use of trust funds for collecting, freezing, storing, and shipping of semen from beef cattle sires used in the W-1 project. $12,000.

2. Assist with data analysis and programming

3. Set up a regional semen bank

Dr. Stonaker also suggested that money be made available to pay people such as Dr. Alan Robertson for addressing the W-1 meetings.

The committee felt that proposal No. 1 would be more in line with a regional approach since we are interested in testing these various lines from a number of stations. A good number of the group are involved in this No. 1 proposal.

PROPOSAL FOR USE OF REGIONAL TRUST FUNDS

It is proposed that regional trust funds be made available for the collection, freezing, storing, and shipping of semen from beef cattle sires used in the W-1 project. This would include the twelve cooperating state experiment stations in the Western Region.

Objectives

1. Provide a more adequate control and estimate of genetic improvement for selection experiments
2. Provide an excellent source of genetic material for genetic-environmental interaction studies
3. Provide a method of line evaluation through top-cross tests
4. Provide a readily available source of genetic material for exchange between cooperating stations for W-1 project purposes

Justification

The use of artificial insemination in the beef cattle industry is increasing rapidly and with good success. Artificial insemination is being utilized to a limited degree in beef cattle research programs. Expanded use of this procedure would aid greatly in increasing effectiveness in the research areas listed under the objectives and in improving the total beef cattle breeding research effort.

Many experiment stations are not equipped or financed for continued collection and storage of semen from sires used in their research programs. A few universities and commercial operations provide this complete service at a reasonable cost. Semen could be collected at individual stations and frozen, stored, and shipped at one or more central locations.

Proper control populations for estimating genetic improvement has long been a major problem in large animal selection experiments. An effective method for providing this estimate of genetic change can be obtained through the use of semen from sires on the selection experiment over a period of time. Semen from these sires representing different generations can be utilized concurrently in one large herd and the progeny compared. Differences between older and current sires provide an estimate of genetic change. This procedure is continuing over time with the older sires being dropped and more current sires being added each time semen from a particular line is used. This method is presently being used in a very

limited way at a limited number of stations. The adequate use of this procedure would strengthen all existing selection studies.

An effective procedure for studying the importance of genetic-environmental interactions is to use the same genetically diverse stocks over a wide range of environmental conditions. Inbred lines of the same breed and sires from different breeds are an excellent source of stock for this purpose. Semen from sires in existing inbred lines and crossbreeding projects could be used. Again, this procedure already is being used within the region, but to a limited extent. More information in this area could be obtained in a relatively short period of time through greater use of artificial insemination.

Several lines of cattle at various experiment stations in the Western Region have been developed since and before the initiation of W-1. Topcrossing to provide information on the desirability of this method of producing seed stock for commercial production has not been practiced adequately in conjunction with line development. Semen from these lines could be used to strengthen this area at a relatively low cost.

Exchange of genetic stocks between stations has occurred to a limited extent. Usually this has been accomplished through transfer of bulls, and to a lesser extent through shipment of semen. An accessible supply of semen from these stocks would enhance this exchange when desired.

Estimated annual budget:

Collecting, processing, and freezing of semen from 75 bulls - 150 ampules/bull @ $0.60 per ampule	$6,750
Annual storage of semen	2,000
Shipping, nitrogen, rental on units	1,250
Transportation, meals, and lodging involved in collection	2,000
Total	$12,000

The committee recommends that this be considered as a request to the Directors for use of trust funds, and I so move.

Dr. Bailey seconded the motion.

Discussion followed concerning the availability of cows for such tests. It was pointed out that cooperators' herds are now being

used and are an excellent source in addition to experiment station herds for this purpose. Two states have cooperator herds numbering 1,000 cows available and others have from 300 to 500 that could be used in tests of this nature. There was some discussion on the use of these funds for obtaining semen from foreign countries.

Dr. Bogart called for the question. Motion carried.

There was additional discussion on the use of these funds for travel and honorariums for guest speakers at W-1 meetings. It was pointed out that it would be preferable to have the home state each year pay this from P & C funds if possible.

There was further discussion on which state should handle these funds and submit the necessary CSRS Form 20 should the Directors approve the proposal.

Dr. Cobb moved that the possibility of assigning this trust fund to the Colorado station be investigated. The persons to check this out will be Drs. Brinks, Stonaker, and the new chairman.

Dr. Bogart seconded the motion. Motion carried.

Committee: G. E. Nelms, C. B. Roubicek, and Estel Cobb

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Dr. Rollins called for the report of the Committee on Regional Project Objectives.

Dr. Bogart (Chairman) read the following report:

> The Committee appointed to study and make recommendations on revising the W-1 Project Plan has made a thorough study of the present outline and of the work that is being done at the various stations. In addition, all members of the W-1 Technical Committee have been consulted to obtain their opinions.
>
> It appears that the present outline covers in an adequate manner the research that is being done without imposing any severe restrictions. It also appears that the present outline is sufficiently specific to give administrators a complete understanding of the research that is being done.
>
> Your committee recommends that the project outline is adequate and needs no revision for the next five years. We further recommend that the project outline be reviewed again at the end of 1970 to determine the revisions that are necessary.

C. M. Bailey
J. A. Bennett
Ralph Bogart, Chairman

Dr. Bogart moved that the report be accepted.

Dr. Nelms seconded the motion.

Dr. Bailey pointed out that there is a difference in work being carried out at the stations now as compared with the early work described in the 1956 project outline. Specifically, there is more emphasis on genetic-environmental interaction studies, effectiveness of selection studies, and studies involving artificial insemination procedures. He felt these differences were large enough to warrant a project revision. He did point out that the work being done could fit the present objectives in a general way, and he suggested that if a project revision is not necessary then it be delayed until 1970 rather than bringing it up every year.

Dr. Rollins pointed out that the W-1 project has a new Administrative Adviser, and it might be well to continue with the present project outline until he becomes more acquainted with the project.

Dr. Bennett called for the question. Motion carried.

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Dr. Rollins called for the report on Regional Bulletins.

Dr. Brinks (Chairman) read the following report:

The development of inbred or closed lines has received much emphasis in the overall beef cattle breeding research effort in the Western Region. At the 1964-65 meeting, a series of regional bulletins on this topic was discussed and a committee was subsequently appointed.

The committee recommends that a series of four regional bulletins be published from data on past and current research in the region. These would be:

Studies on Inbred Lines of Beef Cattle

I. Effects of Inbreeding

II. Response to Selection

III. Hybrid Vigor from Linecrossing and Topcrossing

IV. The Importance of Genetic-Environmental Interactions

It is proposed that these be written in the order listed, with completion of the final bulletin in about 1970 or 1971. Data for the first bulletin (Effects of Inbreeding) should be assembled by January 1, 1966, and a rough draft completed by June 1, 1966.

A proposed general outline for the first two, to be used as initial guides, is below. Outlines for the latter two could be formulated in the next two years.

I. Effects of Inbreeding

  A. Effect of inbreeding of sire, dam, and mating on fertility

  B. Effect of inbreeding of calf and dam on calf survival

  C. Effect of inbreeding of calf and dam on weights, gains, scores, and feed efficiency

  D. Interaction of levels of environment with levels of inbreeding

II. Response to Selection

  A. Intensity of selection
    1. Selection differentials
    2. Selection indices actually practiced

  B. Expected response

  C. Estimated actual response
    1. Phenotypic trends
    2. Genetic trends

  D. Comparison of expected and actual response

The committee recommends that all contributors be included as authors with the senior authorship of each bulletin going to the one assuming responsibility for assembling the material in manuscript form.

It further recommends that the method of publication (state, Federal, or other) be resolved through discussion at this meeting.

H. H. Stonaker
O. F. Pahnish
J. S. Brinks, Chairman

The method of publication was discussed. Dr. Temple, S-10 Investigations Leader, stated that their regional bulletins are published under a regional series number with no state number being shown. It was decided to inquire whether a regional series has been developed in the Western Region, or if the Western Directors require a state number such as the last W-1 regional bulletin bore.

Both the merits and problems associated with a regional publication were discussed quite thoroughly. The merits of bringing together enough data on a given subject to substantiate conclusions, of establishing general patterns of response to inbreeding, and whether large numbers of lines differ greatly in their response to inbreeding, were pointed out. The question of how a regional bulletin would affect state work on both published and unpublished material was discussed. Several thought it would have little effect since each state might go into more detail on specific items or traits. Some thought it might affect future graduate student studies. It was pointed out that a regional analysis may pose many interesting problems as well as answering several.

The question of authorship was discussed. There was general agreement that all committeemen contributing data should be included as authors and that they should assume responsibility for contributing ideas on the types of analyses and also in writing and editing the various drafts.

Professor Flower moved that the committee report be accepted.

Dr. Bogart seconded the motion.

After further discussion, Dr. Cobb called for the question.

Motion carried.

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Dr. Rollins called on the Cooperative State Research Service representative, Dr. Martin J. Burris, for comments. Dr. Burris handed out the following notes of interest:

1. On August 4, 1965, Public Law 89-106 was enacted, in part providing the Secretary of Agriculture with the authority to make research grants to a wide range of recipients. This will also extend existing authority (under Public Law 85-934) to include applied research. It is assumed CSRS will obtain authority to make grants under this law in areas of both applied and basic research.

2. Some centralization of action on grants from USDA has been achieved as indicated in our letter of October 26, 1964 to Station Directors. Of some 230 research proposals submitted by state stations, some 73 have been or will be funded. CSRS has acted with other agencies in the department in a screening and coordinating function to assure maximum possible support of these proposals. $4,000,000 has been committed for these projects.

3. Proceedings of the Conference on Estrous Cycle Control in Domestic Animals, held at Lincoln, Nebraska on July 9 and 10, 1964, are now available from Dr. Carl Sierk, CSRS. Also, a visual aid album (bulletin) entitled Artificial Insemination of Livestock in USSR, has been translated and copies are available from your library or may be obtained through your Station Director.

4. A task force was established in the fall of 1964 to study current livestock research (expenditures and scientists) and needs projected to 1970. The current research program includes state station livestock research, $60 million, 2200 pmy; beef production USDA and state stations, $12.6 million and 340 pmy. Sources of funds for livestock research at state stations include state appropriations 44%; Federal grant (CSRS) 23%; Income sales, etc. 16%; Other sources, 17%. Projected research needs are in excess of 50% in most areas.

5. Senate Bill S 774 (HR 38) to study the possible effects of adoption of the metric system in the United States has been introduced in Congress.

6. A mimeograph publication, Information on Laboratory Animals for Research, is available from the Institute of Laboratory Animal Resources, National Academy of Sciences - National Research Council, 2101 Constitution Avenue, N. W., Washington, D. C. 20418. This periodical carries information on meetings, legislation, and relevant publications.

7. The U. S. Department of Agriculture amended its Meat Inspection Regulations in January 1965 to set forth procedures for acceptance or rejection for food of animals used in experimental research that are to be slaughtered at Federally inspected plants.

8. It is understood that Food and Drug Administration, Health Education, and Welfare, will soon publish in the Federal Register proposed amendments for authorizing marketing of edible products of experimental animals and for use of new drugs in investigational use. The Research Animal Committee of American Society of Animal Science and numerous other groups have met with Food and Drug Administration officials in an attempt to make these amendments less restrictive than those proposed in the June 19, 1964 issue of the Federal Register.

9. On June 1, 1965, HR 8665, A Bill to require Federal inspection of slaughter for human food purposes of animals used in research was introduced in Congress. The Bill covers cattle, sheep, swine, goats, reindeer, horses, and poultry in which animals were subjected to the causative agent of any disease or any chemical, radiation, or other force capable

of affecting the animal or any of its biological processes in any way.

10. Again several bills have been introduced in Congress dealing with scientific study of animals. HR 5191 is considered to be a constructive bill by certain research animal organizations, while S 1087, HR 5647, HR 3036, HR 7312 are considered restrictive on research. Copies of these bills are available from the Senate and House Document rooms, respectively. Other bills of interest to this committee are S 2322 (or HR 9869), Transport of Experimental Animals, HR 10049, Treatment of Experimental Animals, and S 2281 (or HR 9955), Environmental Research.

11. At latest word, the Agricultural Appropriation Bill, 1966, was being discussed by conferees of the House and Senate to iron out differences in appropriations approved by the two houses. The Senate had recommended a $4 million increase in funds for CSRS including $1 million Hatch for pay admustments, $1 million for forestry grants, and $2 million for basic research grants. These amounts are in addition to increases of $2 million for Hatch and $1 million for forestry previously recommended by the House of Representatives. Appropriations for fiscal year 1965 were approximately Hatch $45 million, $1 million forestry, and $3 million facilities.

Dr. Burris:

I personally am encouraged by the wholehearted support of everyone who is contributing data to the suggested regional publications. On the other hand, if I were Dr. Stonaker I would not be reluctant to ask anyone to supply data he may have. I think this is a part of the feeling and attitude regional research should have. I might say, too, that we talk about individual projects and the regional project, but I feel that the contributing projects rise and fall a lot with the prestige the regional project has, and that prestige depends a lot on how we are able to impress the Directors with the work we are accomplishing. The tremendous number of publications has been mentioned. I know every man needs to publish. At the same time, we need to have comprehensive publications showing what we have. We have a responsibility of some sort for putting this together in a unified approach.

I do think we need to contact our new Administrative Adviser directly after the meeting and let him know what has gone on here, particularly this trust fund thing, for he is the one who has to go to bat and he needs quite a bit of ammunition if he is going to get that money.

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Dr. Rollins called on Dr. E. J. Warwick, Beef Cattle Research Branch, for comments.

Dr. Warwick:

One thing should be discussed so it is understood, and that is this fund situation. Two years ago I discussed in some detail with this committee the general policy in ARS. It was felt by some that where ARS was putting relatively small sums of money into state projects we were in effect not helping the project too much and perhaps these funds would be more worthwhile if they were concentrated on one project where they would be a major factor. Following up on that idea, your line testing project in Arizona was developed and some states that had been getting small allocations gave up those allocations at the end of 1964-65 and there were others who had at least informal indication that this fund would be terminated in 1965-66. Two states in that category were Nevada and California. In January the Secretary announced a number of budget cuts and these two states were on the list. A total cut of $5 million was indicated.

Along in the latter part of April the Congress issued a statement in which they recommended that approximately half of the items the Secretary planned to delete from the budget would be retained. These two allotments to Nevada and California were among those the Senate said should be continued. As a result of that, the California and Nevada allotments have been continued. The agreements were continued for one more year, so the future is not determined. In the meantime, we were under obligation to increase the Arizona allocation. We did that by taking away some money from other projects where we could hardly afford to take it away. So I am not sure just how these funds are going to work out. We are in the position of continuing allocations at two stations where we did not expect to continue allocations.

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Dr. Rollins called on Dr. J. S. Brinks, Investigations Leader, W-1, for comments:

Dr. Brinks:

I would like to thank all of you for getting your reports in on time again this year. It appears that W-1 had another prosperous year with research work progressing along project outlines at all stations.

The total cattle inventory in these projects at the twelve state stations and the U. S. Range Livestock Experiment Station amounted to 6,897 head. This inventory was broken down as follows:

Bulls (12 months and over)	600
Cows (2 years and over)	3,303
Yearling heifers	811
Heifer calves	1,050
Male calves	1,133

Included in these figures are the Apache Indian Agency herd San Carlos, Arizona, and the Hawaiian Ranch Company herd in Hawaii. In addition, in cooperators' herds there were 290 cows at the Kahua Ranch Company in Hawaii and 100 and 300 in Oregon and Wyoming herds, respectively. These cows were inseminated with semen from bulls in the Arizona project.

There was a total of 62 publications reported this year. This includes both popular presentations and journal papers. The list is reported at the end of each station report. I might remind you that a credit line showing the paper is a contribution to W-1 should be included in your journal papers.

As far as our immediate office is concerned, we are very happy with the space that Colorado State University has provided us. We are utilizing the statistical laboratory on campus but in addition are maintaining our work at the Bureau of Standards in Boulder for larger analyses.

We are happy to have Brad Knapp, who joined our staff the middle of June this year. He comes to us from Biometrical Services and is a real expert in computer programming and data analysis. He certainly will help our program along immensely.

Also, I would like to mention that Mrs. Neely has received a Sustained Outstanding Work Performance Award. The certificate and cash award should be forthcoming. We certainly appreciate her outstanding work and service in our office.

I had hoped to distribute copies of the papers that were presented at the Animal Husbandry Research Division Inter-Branch Genetics Conference earlier this year, since the theme of that conference was similar to our own symposium. We will send each of you copies when we receive them if enough are available.

If we can help in any way in assembling the data for the regional bulletins, please let us know. I feel these bulletins will be a real contribution to the regional effort.

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Dr. Rollins called for nominations for the new chairman.

Dr. Bogart moved that Dr. Stonaker be the next chairman.

Dr. Nelms seconded the motion. Motion carried.

Dr. Rollins brought up the subject of location for next year's meeting and stated that the Western Section meetings are to be in New Mexico on July 10 to 12.

Dr. Bogart moved that we meet just in advance of the Western Section meetings in New Mexico.

Dr. Bennett seconded the motion. Motion carried.

The specific dates are to be worked out by the Executive Committee.

Dr. Rollins called for other business.

Dr. Brinks commented on the reporting forms for the annual report and asked for comments and suggestions.

Discussion followed pointing out some of the problems and indicating some simplification would be helpful. Dr. Brinks is to work out a new suggested form and circulate it to the committee.

Dr. Bogart suggested that committeemen resume the practice of sending 75 copies of published papers to the Regional Office for distribution.

Dr. Rollins called for the report of the Resolutions Committee.

Dr. Cobb read the following resolution:

> BE IT RESOLVED, That the W-1 Technical Committee express its thanks to Dr. H. H. Stonaker for making the arrangements for our meeting and for his Western hospitality. The committee requests that Dr. Stonaker convey our thanks to his colleagues and administration for their help and cooperation in making this meeting a success.

Dr. Warwick suggested that a personal letter be sent from the chairman to Mrs. Stonaker expressing appreciation for their hospitality.

Dr. Roubicek moved that the W-1 Technical Committee express its appreciation to Dr. Alan Robertson for his contributions to our meeting.

Dr. O'Mary seconded the motion. Motion carried.

Chairman Rollins is to write the letter.

Dr. Cobb moved it be made a matter of record that we send to Dr. Wheeler, past W-1 Administrative Adviser, an expression of our gratitude for his services.

Dr. Roubicek seconded. Motion carried.

This letter of appreciation was written by Drs. Bogart, Bennett, and Stonaker. This is to be printed, framed, and presented to Dr. Wheeler.

Dr. Bogart moved the meeting be adjourned.

ADJOURNED

Dear Dr. Wheeler:

We, the members of the W-1 Technical Committee, extend our thanks to you for your guidance and advice during the past twelve years in your capacity as Administrative Adviser. Your service in helping to make the Western Regional Beef Cattle Breeding Project a most successful research effort is appreciated by each and every member of the committee.

Carl Roubicek | Lewis A. Holland
W. C. Rollins | Ralph Bogart
H. H. Stonaker | Floyd Pahnish
Estel Cobb | James A. Bennett
Ross Christian | Clayton C. O'Mary
Alva E. Flower | George Nelms
Curtis M. Bailey | James S. Brinks

September 7, 1965

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U. S. DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

ANIMAL HUSBANDRY RESEARCH DIVISION

and

COOPERATING WESTERN STATES

W-1 IMPROVEMENT OF BEEF CATTLE THROUGH THE APPLICATION OF BREEDING METHODS

1964 Annual Report of W-1

and

Report of

Annual Meeting of Technical Committee

Honolulu, Hawaii

January 18 to 21, 1965

This report is intended for the use of administrative leaders and workers and is NOT for general publication.

1964

Annual Report of W-1

and

Report of

Annual Meeting of Technical Committee

University of Hawaii

Honolulu, Hawaii

and

Waiakea Experimental Farm

and

Waimea Branch Station

Island of Hawaii

January 18 to 21, 1965

PROGRAM

Dr. O. F. Pahnish, Chairman

January 18, 1965

8:00 A.M.	Welcome to University of Hawaii Dr. George Stanford, Acting Dean and Director, Hawaii Agricultural Experiment Station
8:10 A.M.	Pineapple Breeding and Genetics Dr. J. B. Smith, Geneticist, Pineapple Research Institute
8:55 A.M.	Sugar Cane Breeding and Genetics Dr. John N. Warner, Experiment Station Hawaiian Sugar Planters' Association
10:00 A.M.	Heritability Estimates and Genetic Correlations of Water Consumption in the Laboratory Rat Dr. C. B. Roubicek Animal Science,Department, University of Arizona
10:20 A.M.	Review of Experiments on Genetic-Environmental Interaction in Beef Cattle Dr. E. J. Warwick, Chief, Beef Cattle Research Branch Agricultural Research Service
10:50 A.M.	Design and Analyses of Experiments on Genetic-Environmental Interactions Dr. J. S. Brinks, Investigations Leader Beef Cattle Research Branch, Agricultural Research Service
11:10 A.M.	Discussion
11:30:A.M.	Lunch
11:00 P.M.	Visit Pineapple Research Institute Field Station
to	and
6:00 P.M.	Waialee Livestock Research Farm

PROGRAM
(Continued)

January 19, 1965

8:00 A.M. Discussion of Station Reports

Project Revisions and Reviews

12:00 Noon Lunch

1:00 P.M. Business Meeting

Comments of Administrative Adviser, Cooperative State Research Service Representative, Beef Cattle Research Branch Chief, and W-1 Investigations Leader

January 20, 1965

8:00 A.M. Flight from Honolulu to Hilo

Waiakea Experimental Farm

12:00 Noon Lunch

1:00 P.M. Hawaiian Ranch Company

Night at Kailua, Kona, Hawaii

January 21, 1965

7:30 A.M. Waimea Branch Station

11:30 A.M. Lunch at Kamuela

1:00 P. M. Flight from Kamuela to Honolulu

ADJOURNED

CONTENTS

ANNUAL MEETING
W-1 Technical Committee
University of Hawaii
Honolulu, Hawaii

January 18 to 21, 1965

O. F. Pahnish, Chairman

Project Leaders Present	
Arizona	C. B. Roubicek
California	W. C. Rollins
Colorado	H. H. Stonaker
Hawaii	Estel Cobb
Idaho	R. E. Christian
Montana	F. S. Willson
Nevada	C. M. Bailey
New Mexico	A. L. Neumann*
Oregon	Ralph Bogart
Utah	J. A. Bennett
Washington	C. C. O'Mary
Wyoming	G. E. Nelms
U. S. Range Livestock Experiment Station	O. F. Pahnish
Regional Administrative Adviser	S. S. Wheeler
Agricultural Research Service	
Investigations Leader	J. S. Brinks
Chief, Beef Cattle Research Branch	E. J. Warwick
Cooperative State Research Service	
Principal Animal Geneticist	M. J. Burris

*Representing L. A. Holland

Guests Present

Dr. Diedrich Reimer	Dr. Coy Brooks	Dr. Dale Furr
Dr. Oliver Wayman	Mr. Isaac Iwanaga	Dr. Richard Stanley
Dr. Williams Hugh	Dr. Harry Donoho	Dr. Louis Henke

UNIVERSITY OF ARIZONA

I. Station: Arizona Agricultural Experiment Station, Tucson, Arizona

II. Project Title: Breeding and selection of beef cattle for the Southwest

III. Personnel:

Experiment Station:
O. F. Pahnish, project leader, L. W. Dewhirst, W. H. Hale, F. E. Hubbert, Jr., J. F. Kiernat, A. M. Lane, and C. B. Roubicek

Graduate Students:
E. K. Keating, R. L. Roberson, and R. L. Taylor

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, coordinator, and J. S. Brinks

Cooperators:
Apache Indian Agency and Apache Tribe, San Carlos, Arizona
U. S. Range Livestock Experiment Station, Miles City, Montana
Montana Agricultural Experiment Station, Bozeman, Montana
Wyoming Agricultural Experiment Station, Laramie, Wyoming

IV. Nature and extent of work done this year:

The station contributing project was revised. The revision provided for: (1) continued investigation of bovine blood constituents and their relationships with traits of economic importance; (2) continued search for superior genetic material by progeny testing sire prospects from private or experiment station herds; (3) evaluation of the merit of topcross progeny of sires from several inbred lines through topcross x topcross matings and backcrosses with stock carrying the breeding that existed in the experimental herd prior to the introduction of the inbred sires. The latter study will be initiated during the breeding season of 1964.

Collection of data on economically important traits and on blood constituents was continued as outlined in the project plan.

Estimation of genetic, environmental and phenotypic correlations among growth traits, grades and condition scores of bulls and heifers at various ages was continued. Direct and correlated responses expected from single trait selection were also computed. The estimated heritabilities of the various traits were presented in the last annual report. Results of some of the studies here described are in press or in manuscript form.

Analyses of data on blood hemoglobin and plasma phosphorus levels in range cattle are well under way.

An evaluation of plasma cholesterol levels in range cattle (data on two crops of calves) is near completion.

Probable producing abilities were computed for each cow in the experimental herd. Values for both weaning weight and weaning grade were computed.

Information required for an extension of the line project of the Arizona Station was submitted to the Regional Coordinator.

V. Summary of progress:

The principal results of statistical analyses completed during the past year are summarized in the tables. Comments concerning these results are given in the following paragraphs.

Estimates of Correlations and Direct and Correlated Responses

Estimates of genetic, environmental and phenotypic correlations among growth traits, grades and condition scores studied are summarized in tables 1 and 2. Estimates of direct and correlated responses are shown in tables 3 through 6. Weights, grades and condition scores subsequent to birth were collected at weaning (mean age of 230 days), following a stress period of about 117 days after weaning (mean age of 347 days) and at fall yearling age (mean age of 594 days). Gain periods prior to weaning, under stress and between stress and fall yearling weights are hereafter designated as periods 1, 2 and 3. Low gains or weight losses were prevalent during period 2. Analyses of data on bulls through the stress period have been completed. Analyses of data on heifers through fall yearling age have been completed.

Estimates of genetic, environmental and phenotypic correlations among growth traits of bulls are shown in table 1, and the correlations among grades and condition scores of bulls are shown in table 2. Results of the study to date indicated that weight after stress might be about the best single growth trait for which bulls could be selected. This conclusion is based only on the expected responses of other growth traits to such selection. Average daily gain in period 1, however, could not be considered (table 3). Estimates of correlated responses to selection for weight after stress are shown in table 3, as are the estimates of responses to direct selection for the various growth traits. Since selection at weaning time would be more convenient than later selection from the management standpoint, expected responses to selection for weaning weight of bulls are also shown (table 3). All genetic correlations of weaning grade and condition of bulls with the same traits after stress were near zero or appreciably negative (table 2). Estimates of direct and correlated responses to single trait selection for grade or condition score of bulls are shown in table 5. Results of this study indicate that selection for increases

in grade and condition of bulls both at weaning time and after stress would be complicated by negative genetic correlations. On the other hand, contemporary grade and condition were positively and highly correlated genetically. If selection for increases in both traits at weaning time only or after stress only is desired, selection for either grade or condition alone should suffice.

Table 1.--Genetic (G), Environmental (E) and Phenotypic (P) Correlations Among Growth Traits of Heifers (Upper Right) and Bulls (Lower Left)[a]

		Birth wt.	ADG, pd. 1	Wean. wt.	ADG, pd. 2	Weight after stress	ADG, pd. 3	Fall yrl. wt.
Birth wt.	G	...	0.30	0.42	0.30	0.48	-.20	0.17
	E	...	0.18	0.42	-.18	0.32	0.37	0.41
	P	...	0.20	0.42	-.10	0.35	0.24	0.34
ADG, pd. 1	G	1.98	...	0.90	0.04	0.97	0.38	0.83
	E	0.01	...	1.13	-.37	0.70	0.14	0.60
	P	0.09	...	1.08	-.31	0.74	0.21	0.67
Weaning wt.	G	1.12	1.70	...	0.02	0.89	0.21	0.82
	E	0.22	0.94	...	-.28	0.89	0.46	0.65
	P	0.31	0.94	...	-.23	0.89	0.38	0.71
ADG, pd. 2	G	0.46	___	0.21	...	0.63	-.14	0.15
	E	-.30	___	-.53	...	-.02	-.07	0.36
	P	-.09	___	-.42	...	0.10	-.09	0.30
Weight after stress	G	0.96	___	0.81	0.97	...	0.12	0.80
	E	0.10	___	0.90	-.37	...	0.55	0.76
	P	0.29	___	0.85	-.03	...	0.37	0.78
ADG, pd. 3	G						...	1.02
	E						...	0.02
	P						...	0.38

[a]Dashes indicate correlations omitted because of negative sire variance component for period 1 rate of gain in postweaning block of data. ADG is average daily gain. Pd. 1, 2 and 3 are gain periods between weights in order listed at top of table.

Table 2.--Genetic (G), Environmental (E) and Phenotypic (P) Correlations Among Grades and Condition Scores of Heifers (Upper Right) and Bulls (Lower Left)

		Wean. grade	Wean. cond.	Grade after stress	Cond. after stress	Fall yrl. grade	Fall yrl. cond.
Weaning grade	G	...	0.96	1.31	1.01	1.00	0.11
	E	...	0.78	0.38	0.35	0.26	0.36
	P	...	0.83	0.50	0.44	0.38	0.32
Weaning cond.	G	0.95	...	1.04	0.78	0.78	0.23
	E	0.75	...	0.35	0.32	0.29	0.39
	P	0.76	...	0.46	0.41	0.38	0.34
Grade after stress	G	-1.00	-.67	...	1.43	0.99	0.47
	E	0.46	0.41	...	0.44	0.12	0.18
	P	0.42	0.41	...	0.58	0.26	0.22
Cond. after stress	G	-.67	-.00	1.67	...	1.08	0.78
	E	0.37	0.37	0.44	...	0.10	0.12
	P	0.29	0.33	0.53	...	0.27	0.23
Fall yrl. grade	G					...	0.92
	E					...	0.64
	P					...	0.68

Genetic, environmental and phenotypic correlations among growth traits of heifers to fall yearling age are shown in table 1. Correlations among grades and condition scores are shown in table 2. On the basis of expected responses of all observed growth traits from birth to fall yearling age, analyses of the heifer data indicated that fall yearling weight should be about the best single growth trait for which to select. Expected responses of all observed traits to selection for fall yearling weight are shown in table 4, where estimated responses to direct selection for single traits are also presented. Because selection at weaning time would be more convenient than later selection from the management standpoint, growth responses expected from selection for weaning weight are also given (table 4). Contrary to some of the results obtained from the analyses of bull data, all genetic correlations among grades and condition scores of heifers were positive (table 2). Grade and condition of heifers were highly correlated at any given point of observation (weaning, after stress or at fall yearling age). Estimates shown in table 6 indicate that fair responses in grade and condition at all points of observation (relative to responses expected from direct selection) should be obtainable by selecting singly for grade or condition after stress or for fall yearling grade. Selection for weaning grade or condition should result in very good correlated responses by all traits except fall yearling condition. Genetic correlations of grade and condition with contemporary weight of heifers offered little indication that selection for grade or condition would

result in adequate improvement of all growth traits. These correlations and estimated responses are not shown in the following tables. Genetic correlations of weaning grade and condition with weaning weight were 0.21 and 0.41, respectively. Grade and condition after stress were negatively correlated genetically with contemporary weight (-.48 and -.30). Fall yearling grade and condition were essentially uncorrelated genetically with contemporary weight.

Table 3.--Direct and Correlated Responses Expected from Single Trait Selection for Growth Traits of Bulls[a,b]

Trait selected		Birth wt.	ADG, pd. 1	Wean. wt.	ADG, pd. 2	Weight after stress
Direct selection,	(A)	3.04	0.002	2.3	0.065	8.1
each trait	(B)	0.32	0.01	0.05	0.32	0.20
alone	(C)	1.00	1.00	1.00	1.00	1.00
Selection for	(A)	1.20	0.004	2.3	0.005	3.3
wean wt.	(B)	0.13	0.02	0.05	0.02	0.08
	(C)	0.39	2.00	1.00	0.08	0.41
Selection for	(A)	2.31	___	3.8	0.050	8.1
wt. after	(B)	0.24	___	0.08	0.25	0.20
stress	(C)	0.76	___	1.65	0.77	1.00
σ_P		9.49	0.196	46.3	0.204	40.7

[a]Dashes indicate responses omitted because of a negative sire variance component in the postweaning block of data.

(A) Response in actual units of measurement. $\Delta G_u = \sqrt{h_s^2 h_u^2}\ rG_sG_u\ \sigma P_u$
Estimates of genetic correlations in excess of 1.00 were assumed to be 1.00

(B) Response in standard deviation units.

(C) Response expressed as the ratio, $\frac{\Delta G_u}{\Delta G_s}$.

[b]Selection differentials assumed to be one phenotypic standard deviation.

Factors Associated with Growth of Range Cattle

This study was confined to growing heifers and bulls for which observations on all growth traits from birth to fall yearling age were available. Analyses were by least squares procedures within sex classes. The traits studied are indicated in table 7, where least squares means and results of tests of significance of the various effects considered are also shown. Definitions or descriptions of growth traits given earlier in this report are applicable here. Special attention was directed to the evaluation of age-of-dam effects on growth traits observed from birth to fall yearling age

and to interrelationships between weights or gains of sire progenies at various times from birth to fall yearling age.

Table 4.--Direct and Correlated Responses Expected from Single Trail Selection for Growth Traits of Heifers[a]

Trait selected		Birth wt.	ADG, pd. 1	Wean. wt.	ADG, pd. 2	Weight after stress	ADG, pd. 3	Fall yrl. wt.
Direct selection, each trait alone	(A)	1.37	0.044	9.8	0.026	8.3	0.049	22.8
	(B)	.14	.25	.23	.16	.21	.32	.40
	(C)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selection for wean. wt.	(A)	0.74	0.035	9.8	0.001	7.7	0.009	14.2
	(B)	0.08	0.22	0.23	0.01	0.19	0.06	0.25
	(C)	0.54	0.86	1.00	0.04	0.93	0.18	0.62
Selection for fall yrl. wt.	(A)	0.39	0.046	10.6	0.006	9.2	0.054	22.8
	(B)	0.04	0.26	0.25	0.04	0.23	0.36	0.40
	(C)	0.28	1.05	1.08	0.23	1.11	1.10	1.00
σ_P		9.77	0.174	42.5	0.165	39.6	0.152	57.0

[a]Footnotes of table 3 apply.

Table 5.--Direct and Correlated Responses Expected from Single Trait Selection for Grades or Condition Scores of Bulls[a]

Trait selected		Weaning Grade	Weaning Condition	After stress Grade	After stress Condition
Weaning grade	(A)	0.08	0.05	-.04	-.04
	(B)	0.08	0.06	-.06	-.07
	(C)	1.00	1.00	-1.33	-.44
Weaning cond.	(A)	0.06	0.05	-.02	0.00
	(B)	0.06	0.06	-.03	0.00
	(C)	0.75	1.00	-.67	0.00
Grade after stress	(A)	-.05	-.03	0.03	0.04
	(B)	-.05	-.04	0.04	0.07
	(C)	-.63	-.60	1.00	0.44
Cond. after stress	(A)	-.07	0.00	0.06	0.09
	(B)	-.07	0.00	0.08	0.17
	(C)	-.88	0.00	2.00	1.00
σ_P		0.96	0.82	0.71	0.54

[a]Footnotes of table 3 apply.

Table 6.--Direct and Correlated Responses Expected from Single Trait Selection for Grades or Condition Scores of Heifers[a]

Trait selected		Weaning Grade	Weaning Cond.	After stress Grade	After stress Cond.	Fall yrl. Grade	Fall yrl. Cond.
Weaning grade	(A)	0.27	0.28	0.13	0.13	0.15	0.01
	(B)	0.24	0.26	0.18	0.20	0.18	0.01
	(C)	1.00	0.82	1.44	1.18	1.36	0.12
Weaning cond.	(A)	0.30	0.34	0.15	0.15	0.14	0.03
	(B)	0.27	0.32	0.21	0.23	0.16	0.04
	(C)	1.11	1.00	1.67	1.36	1.27	0.38
Grade after stress	(A)	0.20	0.22	0.09	0.10	0.11	0.04
	(B)	0.18	0.21	0.13	0.15	0.13	0.05
	(C)	0.74	0.65	1.00	0.91	1.00	0.50
Cond. after stress	(A)	0.22	0.24	0.11	0.11	0.12	0.08
	(B)	0.20	0.23	0.15	0.16	0.14	0.11
	(C)	0.81	0.71	1.22	1.00	1.09	1.00
Fall yrl. grade	(A)	0.20	0.17	0.09	0.10	0.11	0.08
	(B)	0.18	0.16	0.12	0.15	0.13	0.11
	(C)	0.74	0.50	1.00	0.91	1.00	1.00
Fall yrl. cond.	(A)	0.02	0.05	0.04	0.07	0.09	0.08
	(B)	0.02	0.05	0.05	0.11	0.11	0.11
	(C)	0.07	0.15	0.44	0.64	0.82	1.00
σ_P		1.11	1.06	0.73	0.66	0.85	0.74

[a]Footnotes of table 3 apply.

Table 7.--Least Squares Means and Significance of Effects of Sires and Environmental Factors on Weights and Gains of Heifers and Bulls

Item[a]	Birth wt.	ADG, pd. 1	Wean. wt.	ADG, pd. 2	Stress wt.	ADG, pd. 3	Fall yrl. wt.
			Heifers (N = 292)				
μ (lb.)	80.1	1.59	445	-.15	433	1.29	749
Year	NS	**	**	**	**	**	**
Age of dam	NS	NS	NS	NS	NS	NS	NS
Sire	NS	**	**	*	**	**	**
Age of animal	NS	NS	**	**	**	NS	**
			Bulls (N = 269)				
μ (lb.)	82.2	1.74	484	-.24	459	1.26	766
Year	NS	**	**	**	**	**	**
Age of dam	*	**	**	NS	**	NS	**
Sire	*	NS	NS	**	*	**	**
Age of animal	NS	NS	**	**	**	NS	**

[a]Four years, dams 3 through 11 years of age, and 17 sires.
NS, P > .05; * P < .05; ** P < .01.

Year effects on all traits except birth weight (table 7) were significant ($P<.01$). Year differences appeared to be attributable largely to variations in quantity or quality of range forage. Effects of age of animal on weaning weight, weight after stress and fall yearling weight were important ($P<.01$). The regressions of weights on age were all positive. Age of animal affected daily gains significantly during period 2 only. During period 2, weight changes were primarily negative (table 7). Regressions of gains on age for period 2 were -.0018 and -.0023 for heifers and bulls, respectively. The younger animals apparently withstood the stress of weaning and the ensuing winters better than did animals more advanced in age, as judged by weight changes during period 2.

Age of dam had little influence on growth traits of heifers, but all growth traits of bulls except daily gains during periods 2 and 3 were significantly affected (table 7). Constants from least squares analyses of age-of-dam effects on weights and gains of bulls are shown in table 8. It appears that the effects of age of dam on stress and fall yearling weights were largely reflections of effects imposed on growth up to weaning time while the calves were under direct cow influence. It does appear that postweaning as well as weaning weights of bulls should be adjusted for age-of-dam effects if these weights are used as selection criteria. Age-of-dam effects on daily gains of bulls were significant for period 1 only. The curves of gain in period 1 and weaning weight of bulls plotted against age-of-dam were similar in shape and bore considerable resemblance to curves generally reported in the literature. Although effects of age-of-dam on daily gains of bulls during periods 2 and 3 were nonsignificant, there was a tendency for the age-of-dam curve to reverse in shape during period 2 (the stress period) and to again approach the shape of the curve for preweaning gain during period 3 when the growth environment was again more favorable.

Table 8.--Constants[a] for Age-of-Dam Effects on Weights and Gains of Bulls from Least Squares Analyses

Age-of-dam	Weights				Daily gains		
	Birth	Wean.	After stress	Fall yrl.	Pd. 1	Pd. 2	Pd. 3
(yr.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
3	-6.1	-27	-18	-29	-.091	0.084	-.048
4	-1.0	-23	-20	-31	-.101	0.013	-.043
5	- .2	- 1	0	- 8	0.002	0.016	-.032
6	0.5	0	- 3	2	-.004	-.035	0.020
7	3.1	18	11	16	0.067	-.054	0.024
8	0.5	3	- 7	- 6	0.017	-.081	-.000
9	4.0	21	28	36	0.074	0.053	0.035
10	2.2	- 1	5	1	-.017	0.042	-.019
11	-3.0	10	4	19	0.053	-.038	0.063

[a]Constants expressed as deviations from the general mean.

Sire effects on all weights and gains of heifers except birth weitht and on all weights and gains of bulls except gain in period 1 and weaning weight were significant (table 7). Rank correlations of sire constants for all observed weights and gains within sex of progeny are shown in table 9. These results indicate considerable agreement of sire rankings based on weaning, stress and fall yearling weights within sex of progeny. In most cases sire rankings based on daily gains during periods 1, 2 and 3 within sex of progeny were in rather poor agreement. Correlations of sire rankings based on like traits in progeny of opposite sex were generally low to moderate in size, although the correlations of rankings based on weaning weights, daily gains in period 3 and fall yearling weights (0.54 to 0.57) were significant ($P<.05$).

Table 9.--Rank Correlations of Sire Constants for Weights or Gains of Heifer Progeny (Upper Right) Bull Progeny (Lower Left) and Like Traits in Opposite Sexes (Main Diagonal)

	Birth wt.	ADG, Pd. 1	Wean. wt.	ADG, Pd. 2	Stress wt.	ADG, Pd. 3	Fall yrl. wt.
Birth wt.	<u>0.41</u>		0.41		0.47		0.47
ADG, pd. 1		<u>0.46</u>		-.06		0.24	
Wean. wt.	0.51*		<u>0.54*</u>		0.85**		0.79**
ADG, pd. 2		-.18		<u>-.06</u>		-.12	
Stress wt.	0.53*		0.86**		<u>0.23</u>		0.77**
ADG, pd. 3		0.70**		0.17		<u>0.57*</u>	
Fall yrl.wt.	0.41		0.82**		0.88**		<u>0.57*</u>
Range of sire constants							
Heifers	-5.7 to 11.1	-.10 to 0.20	-27 to 55	-.13 to 0.11	-31 to 55	-.12 to 0.08	-40 to 50
Bulls	-5.4 to 11.6	-.13 to 0.11	-35 to 28	-.18 to 0.18	-29 to 55	-.14 to 0.29	-62 to 116

* $P < .05$; ** $P < .01$

Blood Hemoglobin and Plasma Phosphorus Concentrations

Blood hemoglobin and plasma phosphorus concentrations in range cattle born in 1958, 1959 and 1960 were studied. Collection of blood samples coincided with the collection of weaning weights, weights after stress and fall yearling weights at mean ages of 235, 342 and 599 days, respectively. Some of the results of least squares analyses of data on range heifers are summarized in table 10. Mean values for hemoglobin and phosphorus concentrations from the least squares analyses (table 10) are in reasonable agreement with values reported in the literature. Blood hemoglobin concentration after stress was about 1.8 gm. per 100 ml. below the concentrations at weaning and fall yearling ages, and plasma phosphorus concentration at fall yearling age was 0.6 to 1.0 mg. per 100 ml. below the concentrations at the earlier ages. The differences between collection periods were not tested for significance, however. All concentrations within collection periods varied from year to year ($P<.05$) and were influenced by age of animal ($P<.05$) except phosphorus concentration at fall yearling age. The ranges of year constants are shown in table 10, as are the coefficients for regressions of hemoglobin and phosphorus concentration on age of animal within collection period. Within collection periods, hemoglobin and phosphorus concentrations generally decreased with age of animal. Hemoglobin concentration at fall yearling age was the single exception. Neither hemoglobin nor phosphorus concentration was influenced significantly by age of dam or sire at any point of observation.

Table 10.--Effects of Sires and Environmental Factors on Blood Hemoglobin and Plasma Phosphorus Concentrations in Range Heifers from Least Squares Analyses

Variables[a]	Weaning Hb	Weaning P	After stress Hb	After stress P	Fall yrl. age Hb	Fall yrl. age P
	N = 254		N = 231		N = 208	
Year	*	*	*	*	*	NS
Age of dam	NS	NS	NS	NS	NS	NS
Sire	NS	NS	NS	NS	NS	NS
Age of Animal	*	*	*	*	*	NS
Least squares means[b]	14.7	6.8	13.0	6.4	14.8	5.8
Range of year constants[c]	-.75 to 0.94	-.51 to 0.80	-.64 to 0.88	-.42 to 0.68	-1.76 to 1.03	-.31 to 0.42
Regression, Hb and P on age[d]	-.0042	-.0089	-.0073	-.0061	0.0038	-.0012

[a]Three years, dams 3 to 11 years of age, 13 sires.

[b]Hemoglobin (Hb) in gm. per 100 ml. whole blood and phosphorus (P) in mg. per 100 ml. plasma.

[c]Expressed as deviations from the general mean.

[d]Change per day of age.
NS, $P > .05$; * $P < .05$; ** $P < .01$

Plasma Cholesterol Concentrations

Plasma cholesterol concentrations in range cattle born over a period of two years were analyzed by least squares procedures within bull and heifer classes. Progeny of 12 Hereford sires were involved. Collection of blood samples coincided with collection of weaning weights (235 days of age), weights after postweaning stress (340 days of age), fall yearling weights (600 days of age) and weights after second winter (710 days of age). Some of the results of the data analyses are summarized in table 11. Mean cholesterol concentrations (mg. per 100 ml. of plasma) showed some tendency to decrease from 235 to 710 days of age, although this trend was not entirely consistent (table 11). Effects of age variation within time of collection were generally unimportant. Year effects on cholesterol concentrations for both bulls and heifers were significant only at 235 and 600 days of age. Age of dam effects were unimportant throughout the study. Sire effects were in most cases, nonsignificant (table 11). Heritabilities of cholesterol concentrations estimated by the paternal half-sib method were primarily in the low range, the largest being estimates of 0.46 and 0.37 for the heifer class at the mean ages of 235 and 600 days, respectively.

Table 11.--Effects of Sires and Environmental Factors on Plasma Cholesterol Concentrations in Range Bulls (B) and Heifers (H) from Least Squares Analyses

Variables[a]	Sex	Approximate mean ages in days: 235	340	600	710
	B	N = 167	N = 110	N = 99	N = 86
	H	N = 167	N = 150	N = 133	N = 109
Year	B	**	NS	**	NS
	H	**	NS	**	**
Age of dam	B	NS	NS	NS	NS
	H	NS	NS	NS	NS
Sire	B	NS	NS	NS	NS
	H	**	NS	*	NS
Age of animal	B	*	NS	NS	NS
	H	NS	NS	NS	NS
Least squares mean[b]	B	148	134	122	120
	H	146	124	118	140
Heritability estimates[c]	B	0.16	0.10	c	0.15
	H	0.46	c	0.37	0.04

[a]Two years, dams 3 to 11 years of age, 12 sires.

[b]Plasma cholesterol concentrations in mg. per 100 ml. plasma.

[c]Heritabilities not computed because of negative sire variance components.

NS, (P > .05); * P < .05; ** P < .01.

VI. Application of Findings:

Estimates of genetic, environmental and phenotypic correlations, heritabilities and responses to selection, in combination with estimates provided by similar studies elsewhere, will contribute to the formulation or refinement of selection procedures for the improvement of important beef cattle traits. Evaluation of environmental effects that normally can not be controlled adequately by management, and appropriate adjustment for such effects, will increase the accuracy of selection for genetic merit.

The study of blood constituents (of which the analyses of blood hemoglobin, plasma phosphorus and plasma cholesterol data are a part) will yield information concerning normal values for these constituents in range cattle. Information concerning the influences of inheritance and certain environmental variables on these values is being accumulated. Information of the type described can be useful in a variety of other beef cattle investigations. Carried to completion, this study will provide indications of the probable value of blood constituents as aids in identifying animals that are genetically superior for important traits.

VII. Work Planned for the Future:

Continue analyses of growth and blood data collected to date. These studies will include evaluations of environmental effects and estimates of genetic parameters from blocks of data that are now of sufficient size.

Continue collection of growth and blood data as required under the provisions of the project plan.

Continue evaluation of topcross progeny of inbred lines through topcross x topcross and backcross tests.

Progeny test promising sires from private or experiment station sources in a search for superior genetic material or in an endeavor to evaluate existing beef cattle lines if the opportunity for the latter should arise.

VIII. Publications:

Pahnish, O. F., J. S. Brinks, R. L. Roberson, C. B. Roubicek, and R. T. Clark. 1964. Factors associated with growth of range cattle. Amer. Soc. Anim. Sci. West. Sect. Proc. 15:IV.

Pahnish, O. F., R. L. Roberson, R. L. Taylor, J. S. Brinks, R. T. Clark, and C. B. Roubicek. 1964. Genetic analysis of economic traits measured in range-raised Herefords at preweaning and weaning ages. J. Anim. Sci. 23(2):562-568.

IX. PROJECT SUMMARY

Cattle Inventory

Purebred ________ Arizona Agricultural Experiment Station

Breed	Hereford
Line	Apache Tribal Herd
Station	Arizona
Bulls (12 mo. or over)	107
Cows (2 yrs. or over)	465
Heifers (yearling)	166
Bull calves	160
Heifer calves	160
Estimated cash value[1]	$270,000

[1]Cooperative project. No accurate method of determining percentage use for breeding project.

Land, physical facilities and equipment

	Amount	Actual cash value	Percentage use for breeding project
Apache Reservation[1]:			
Land	35 sections	$560,000	
Fencing	65 miles	32,000	
Corrals and scales		8,000	
Water supply		20,000	
Total		$620,000	
Experiment Station:			
Laboratory facilities		$25,000	25

[1]Land, equipment and facilities owned by private operators. No accurate method of determining percentage use for breeding research.

Arizona Agricultural Experiment Station

Cow Production 1963 calf crop

Breed	Hereford
Line	Apache Tribal Herd
Cows bred to calve as 2-year-olds	None
Calves born from 2-year-olds	None
Cows bred to calve at 3 years and up	452
Calves born from 3-year-olds and up:	
Alive	400
Dead	13
Total	413
Calves weaned	359
Percent calf crop	
Birth[1]	88
Weaning[2]	79

	Bulls		Heifers	
	No.	Av.	No.	Av.
Birth weight	179	80	221	74
Weaning age		247		252
Weaning weight	156	440	203	427
Adjusted weaning weight[3]	156	424	203	393
Weaning score				
Condition		10		11
Conformation[4]		11		11

[1]Calving percentage based on calves born alive and exposed cows still in herd during calving season.

[2]Weaning percentage based on calves weighed at weaning time and cows in herd during calving season, less cows sold before weaning with calves at side

[3]Weights adjusted to 230 days of age and to a mature dam basis.

[4]Score based on feeder grade. Scores of 10, 11 and 12 are low, middle, and high choice, respectively.

UNIVERSITY OF CALIFORNIA

I. Station: California Agricultural Experiment Station, Davis, California

II. Project title: The genetics and biology of bovine achondroplasia

III. Personnel:

Experiment Station:
F. D. Carroll, P. W. Gregory, T. J. Hage, L. M. Julian, Clyde Stormont, and W. S. Tyler

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done and application of findings:

Many grades of bovine achondroplasia--compact, comprest, the brachycephalic and dolichocephalic dwarfs, the Dexter, and others-- are conditioned by heredity and are components of the same complex. Each is subnormal in size and / or produces lethals. Some variants show hydrocephalous with early death while others live indefinitely but are unthrifty and unprofitable. Achondroplasia is responsible for a substantial part of the calf crop loss in commercial and registered herds; furthermore, it is responsible for some of the deterioration within registered and commercial herds.

Intensive selection for low-set, compact, early-maturing animals was effective in Hereford, Angus and the Shorthorn breeds. Several gene substitutions can explain the parallel enforced directional evolution that has occurred in each of these breeds. Alleles occupying one major locus and several minor loci are indicated. Most "carrier" cows donated by breeders for progeny testing were heterozygous for achondroplasia at the major locus, but the comprest testers were homozygous for achondroplasia at the major locus but carried homeostatic buffer genes at the minor loci. Tests indicate that segregation at 2 or more loci produces the same type of achondroplastic dwarfs. Test progeny cannot be classified by visual inspection. This information, although fragmentary, is of great value to scientists that are presently or potentially interested in basic genetic and biological problems of cattle and to other scientists interested in problems of growth and development. More work is essential before it would interest the breeder. The evidence indicates that the correction necessary to eliminate dwarfism may be made by a gene substitution at the major locus but it is possible that the animals may not be acceptable to either the industry or the breeder; if this proves to be true, the correctional gene substitutions will have to be made at the minor loci.

VI. Work planned for the future:

This project has been discontinued and will be continued as a state project.

VII. Publications:

Gregory, P. W., L. M. Julian, and W. S. Tyler. 1963. Progeny testing for achondroplasia. (Abs. 17.) J. Anim. Sci. 22(3):818.

Gregory, P. W., L. M. Julian, and W. S. Tyler. 1963. Progeny testing for achondroplasia. Genetics 48(7):891-892.

Gregory, P. W., C. E. Shelby, and R. T. Clark. 1963. Growth of Hereford cows selected and rejected for breeding. Growth 27:205-223.

Mayes, J. S., R. G. Hansen, P. W. Gregory, and W. S. Tyler. 1963. Mucopolysaccharide excretion in dwarf cattle. (Abs.) Fed. Prod. 22(2):412.

Tyler, W. S., P. W. Gregory, and L. M. Julian. 1963. Expression of achondroplasia in bovine dolichocephalic mutants. (Abs. 35.) J. Anim. Sci. 22(3):823.

Julian, L. M., W. S. Tyler, and P. W. Gregory. 1964. Expression of modified achondroplasia in domestic cattle as reflected by early closure of the spheno-occipital synchondrosis. (Abs.) Anat. Rec. 148:296.

Mayes, Jary S., R. T. Hansen, Paul W. Gregory, and Walter S. Tyler. 1964. Mucopolysaccharide excretion in dwarf and normal cattle. J. Anim. Sci. 23(3):833-837.

VIII. Achondroplastic herd inventory - June 1, 1964:

	Type	No.	Totals
1.	Brachycephalic dwarfs		
	Females, mature	28	
	Females, yearlings	1	
	Bulls, mature	3	32
2.	Dolichocephalic dwarfs (heavy bone)		
	Females, mature	21	
	Females, yearlings	1	
	Bulls, mature	1	
	Bulls, yearlings	1	24

Achondroplastic herd inventory (continued)

	Type	No.	Totals
3.	Dolichocephalic dwarfs (light bone)		
	Females, mature	2	2
4.	Comprest (descend. of Colo. Dom. 68)		
	Females, mature	4	4
5.	Comprest type, (not descend. of Colo. Dom. 68)		
	Females, mature	6	
	Bulls, yearlings	1	7
6.	Synthetic comprest		
	Females, mature (heavy bone)	12	
	Females, mature (light bone)	3	
	Bulls, mature (heavy bone)	2	17
7.	Dexter complex		
	Females, mature (registered or eligible for registration)	5	
	Bulls, mature (registered or eligible for registration	2	
	Females, mature (synthetic Dexter)	3	
	Females, mature (Dexter type segregate)	10	
	Females, mature (Kerry type)	15	
	Bulls, mature (Dexter type)	3	
	Bulls, (Kerry type)	1	
	Unclassified yearlings	16	55
8.	Yearlings (to be autopsied or slaughtered at 16 months)		
	Females	15	15
	Bulls	30	30
9.	1964 calf crop		
	Females and bulls	60	60
	Total		246

UNIVERSITY OF CALIFORNIA

I. Station: California Agricultural Experiment Station, Davis, California

II. Project title: Studies of heterotic effects in crosses of the Angus, Hereford and Shorthorn breeds (Project 1216)

III. Personnel:

Experiment Station:
W. C. Rollins, project leader, F. D. Carroll, J. R. Dunbar, Allan Grunder, R. G. Loy, and K. A. Wagnon

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

The first breeding season resulted in live births only. Calf crop percentages at birth were AA, 72.4%; AH, 78.5%; AS, 66.7%. Number of services per calving were AA, 2.76; AH, 2.50; AS, 3.25. Gestation length averaged 281.4 days for AA matings; 287.8 for AH; and 281.2 for AS. Corresponding average birth weights were 51.6, 58.6 and 53.4 pounds. Calf mortality to about five months of age is 19%, $(\frac{4}{21})$ for AA calves; 0% $(\frac{0}{22})$ for AH; and 15% $(\frac{3}{20})$ for AS.

The calves were bloodtyped and the half of the male calves were castrated at about six to eight weeks of age.

Average daily gain to about four months of age is 1.30 lb/day for AA calves; 1.32 for AH; and 1.49 for AS.

For the second breeding season frozen semen from two Hereford bulls was used: L9 Domino 7 (551342, registered polled Hereford number; P-7418898, registered Hereford number)--a 5% inbred bull bred by the U. S. Range Experiment Station, Miles City, Montana; U. C. Rover Premier 4 (8306193, registered Hereford number)--a 19% inbred bull bred by the U. C. Experiment Station. These bulls will henceforth be referred to as L9 and 287 respectively. The blood types of these bulls are on record.

Cows conceiving neither the first nor second season have been culled. Of 24 heifers failing to conceive the first season 11 conceived the second leaving 13 that did not and hence were culled. Two of these were cystic. A breed breakdown shows that 7% $(\frac{2}{28})$ of the Angus, 21% $(\frac{6}{28})$ of the Hereford, and 17% $(\frac{5}{30})$ of the Shorthorn cows were culled. As of the end

of the second breeding season there remain 26 Angus, 22 Hereford and 25 Shorthorn cows.

Summaries and analyses of data for post partum performance and for conception rates for the second breeding season have not yet been completed.

VI. Application of findings:

Too early to report.

VII. Work planned for the future:

As indicated in last year's W-1 report.

VIII. Publications:

Loy, R. T. 1963. Artificial insemination in the University beef herd and breeding results in estrous synchronization field trials using Provera and artificial breeding. Animal Husbandry Department and Agricultural Extension Service, University of California, Davis. Beef Cattle Day. Mimeog. Rpt. p. 13.

Sittman, K. 1963. Note on the double cervix condition in cattle. J. Hered. 54:112.

Carroll, F. D, W. C. Rollins, and Marian Simone. 1964. Herefords and 1/4 Brahman-3/4 Hereford crossbreds: Comparison of carcasses and meat palatability. J. Agr. Sci. 62:263-266.

Dunbar, J. R. 1964. Level of energy feeding beef breeding cows. Animal Husbandry Department, University of California, Davis. Beef Cattle Day. Mimeog. Rpt. p. 28.

Loy, R. G. 1964. Artificial insemination of beef cattle. Animal Husbandry Department, University of California, Davis. Beef Cattle Day. Mimeog. Rpt. p. 28.

Rollins, W. C. 1964. Progress report of crossbreeding beef cattle. Animal Husbandry Department, University of California, Davis. Beef Cattle Day. Mimeog. Rpt. p. 25.

Rollins, W. C., F. D. Carroll, and N. R. Ittner. 1964. Comparison of the performance of 3/4 Hereford-1/4 Brahman calves with Hereford calves in a variable climate. J. Agr. Sci. 62(1):83-88.

IX. PROJECT SUMMARY

Cattle inventory

	Angus (A) RP*	NRP*	G*	Hereford (H) RP	NRP	G	Shorthorn (S) RP	NRP	G	A x H	A x S
Cows	10		19	23		5	30				
Bulls**				2							
Calves		7	14							22	20
Estimated cash value = $29,800											

* Registered purebred, nonregistered purebred, grade
** Vasectomized

Land, physical facilities and equipment used - June 1964

	Number	Actual Cash value	Percentage used for breeding project
Barns and corrals	3	$100,000	75
Irrigated pastures	46 acres		100
Drylots and pastures	14 acres		100

COLORADO STATE UNIVERSITY

I. Station: Colorado Agricultural Experiment Station, Fort Collins, Colorado

II. Project title: R & M 26. Study of selection, inbreeding and the crossing of inbred lines within the Hereford breed.

III. Personnel:

Experiment Station:
Tom Hall, J. A. Marchello, Glenn Richardson, Kent Riddle, and H. H. Stonaker

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, coordinator, and J. S. Brinks

IV. Nature and extent of work done this year:

Progeny test results from four different herds obtained through artificial insemination. Weaning weights, grades and in some cases carcass information have been presented in the 1964 Field Day Report which bring up to date the comparisons of progeny primarily of Brae Arden 5012 versus other sires. In general this bull continues to show high levels of performance in weaning weights and feedlot daily gain. As a result of the occurrence of cleft palate and or twisted spines in six calves in the Winninger herd at Meeteetse, Wyoming in 1963, test matings of Brae Arden 5012 back to the six dams were made and two abnormal calves were produced in 1964. The possibility of lupine involvement is being tested at Utah State University. As yet, this syndrome has not been found either in the line at the San Juan Basin Station or in the first 30 progeny of sire-daughter matings at Redd Ranches. It should be possible by the end of the calving season to establish at a rather high level of probability the liklihood of this being a simple recessive. The localization of the observations and the involved nature of cleft palate in other species such as man and the mouse make this an interesting problem.

Carcass Comparisons

Detailed carcass analyses on about 120 progeny of various lines at the San Juan Basin have been accumulated over recent years. The number of observations in any one comparison is small and as yet there seem to be no striking differences insofar as a number of carcass observations are concerned. These results are shown in the 1964 Field Day Report.

Milk Production of Beef Cows

Currently in the CSU Dairy we are testing first calf 2-year-old inbred and linecross heifers for milk production. One group is being

milked with the dairy herd and the calves are bottle fed. A second group is being milked but the calf is with the cow the rest of the time, a third group is not milked and the calves are nursing. It should be possible to isolate experimentally the contribution of milk production to weaning weight. To what degree are inbred calves lighter than hybrid calves because of their own inheritance vs. differences in the dams' milk production. This work is under the supervision of E. K. McKellar and Clyde Vair.

Carcass Analysis of Surplus Cows

For the first time, the open cows and other cows culled from the herd have been fed out and slaughtered with detailed carcass observations. It is possible with cows to economically obtain muscle-bone ratios and other information which can best be obtained from complete boning of the carcass. Tenderness, marbling and other characteristics associated with meat quality will be assessed on these cows. These cows are of special interest because they are the dams of replacement heifers and bulls. For example, one cow Prospectita 2009 was the dam of two herd bulls used in the Prospector line. Will these cow carcass analyses indicate trends in carcass characteristics of the lines?

Changes in the Herd which may be Associated with Selection

An analysis is under way in which it may be possible to estimate the changes in weights and gains which may have resulted from selection over the past years. A different approach using a comparison of the correlations or repeatabilities of performance of successive progeny will be undertaken. With this technique the following correlations will be examined on successive calves from:

Repeat matings.

Non-repeat matings in which the calves are maternal half sibs, but the calves are produced by different sires and the calves are in different generations.

Correlation between the weights of maternal half sib calves in which the calves are in the same generation.

With this technique it would appear that there are opportunities for complete randomization of all common effects to the successive calves except that indicated as being due to generation. Thus these generation effects liberated from environmental factors should be indicative of genetic change over generations. Insofar as we are able to determine at this time this offers an opportunity for a novel and yet seemingly fool-proof evaluation of change over a short period of time.

V. Work planned for the future:

No major changes are contemplated, although it is hoped that additional observations and analyses can be recorded on traits which seem to be changing with the divergence of the lines through the continued inbreeding. We are attempting to evolve methods of evaluating particularly the causes of infertility in young bulls.

VI. Publications:

Harwin, Geoffrey Oswald. 1963. The effect of inbreeding and environmental factors on the weaning weight and postweaning growth of range Hereford cattle. Ph. D. Thesis. Colorado State University. Fort Collins.

Stonaker, H. H. 1963. I. Sorting out the goals. II. Does beef conformation have value? III. Sorting out the methods. IV. Putting the goals, methods, and cattle together. Wash. State U. Dept. Anim. Sci. Stockmen's Handb. 14.

Colorado Agricultural Experiment Station. 1964. Beef Cattle Improvement Day and Auction. May 23. General Series 807.

Cattle Inventory
Purebreds

May 31, 1964

	Hereford							
Line	Bonanza	Real Prince	Colorado	Don	Monarch	Prospector	Real Prince	Rover
Bulls (12 mo. or over)	1 + 6	5 + 2	1 + 1	1 + 3	1 + 2	2 + 3	1 + 0	0
Cows (2 yr. or over)	19	46	10	25	20	25	11	9
Heifers, yearlings	1	6	3	4	0	6	9	0
Bull calves[a]								
Heifer calves[a]								
Percentage used for breeding project	100	100	100	0 100	100	100	100	100

	Hereford			HXA-S	Hereford			
Line	Royal	San Juan	Tarrington	Crossbred	Control	Model Domino	On Lease	La Plata
Bulls (12 mo. or over)	2 + 6	2 + 2	1 + 2	0 + 0	1 + 3	0 + 0	4	0
Cows 2 yr. or over)	25	36	30	9	21	1		1
Yearling heifers	4	8	4	0	4	0		0
Bull calves[a]								
Heifer calves[a]								
Percentage used for breeding project	100	100	100	100	100	100	100	100

[a]Because calving is still in progress, details of the 1964 calf crop are not yet available. Approximately 200 calves have been born to date.

Colorado Agricultural Experiment Station

Cow Production Data (By line of dam's sire) 1963 calving

Breed	Hereford					
Line	Bonanza Inbred	Bonanza Linecross	Brae Arden Inbred	Brae Arden Linecross	Colorado Inbred	Colorado Linecross
Cows bred to calve as 2-yr-olds	1	2	5	5	4	1
Calves born from 2-yr-olds						
Alive	1	1	0	0	1	0
Dead	0	0	0	1	1	-
Cows bred to calve at 3 yrs and up	8	10	14	26	4	2
Calves born from 3-yr-olds and up						
Alive	5	5	9	21	3	2
Dead	0	1	2	4	0	0
All calves born						
Alive	6	6	9	21	4	2
Dead	0	1	2	5	1	0
Total	6	7	11	26	5	2
Calves weaned	6	6	9	21	4	2
Percent calf crop						
Birth	68	64	47	84	62	67
Weaning	68	55	47	68	50	67

Calf Data (By line of calf's sire)

	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.
INBREDS												
Weaning age	5	179	1	225	3	178	6	180	2	201	2	203
Weaning weight		334		380		305		294		338		385
Adj. weaning wt. 200 days		441		431		368		394		380		476
Weaning score:												
Conf.		4.8		5.3		4.8		4.5		4.6		4.8
Inbreed. of calf		.51		.39		.49		.47		.38		.47
Inbreed. of dam		.42		.27		.43		.39		.33		.42
LINECROSSES												
Weaning age		-		-	4	199	2	206		-	1	210
Weaning weight		-		-		398		408		-		345
Adj. weaning wt. 200 days		-		-		406		438		-		362
Weaning score:												
Conf.		-		-		4.8		4.5		-		5.7

Colorado Agricultural Experiment Station

Cow Production Data (By line of dam's sire) 1963 calving

Breed	Hereford			H. X A.Sh.
Line	Don Inbred	Don Linecross	Control	Crossbreds
Cows bred to calve as 2-yr-olds	-	2	3	-
Calves born from 2-yr-olds				
Alive	-	2	2	-
Dead	-	0	0	-
Cows bred to calve at 3 yrs and up	10	13	15	9
Calves born from 3-yr-olds and up				
Alive	7	11	14	9
Dead	1	1	1	0
All calves born				
Alive	7	13	16	9
Dead	1	1	1	0
Total	8	14	17	9
Calves weaned	6	13	16	9
Percent calf crop				
Birth	70	87	94	100
Weaning	60	80	89	100

Calf Data (By line of calf's sire)

	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.
INBREDS												
Weaning age	2	191	4	192		-		-		-		-
Weaning weight		392		295		-		-		-		-
Adj. weaning wt. 200 days		467		374		-		-		-		-
Weaning score:												
Conf.		4.2		4.4		-		-		-		-
Inbreed. of calf		.46		.37		-		-		-		-
Inbreed. of dam		.37		.29		-		-		-		-
LINECROSSES												
Weaning age	5	194	5	219	8	196	8	209	7	213	2	216
Weaning weight		412		402		411		394		544		505
Adj. weaning wt. 200 days		437		415		436		421		526		506
Weaning score:												
Conf.		4.9		5.1		5.2		5.1		5.5		5.7

Colorado Agricultural Experiment Station

Cow Production Data (By line of dam's sire) 1963 calving

Breed	Hereford					
Line	Monarch		Prospector		Real Prince	
	Inbred	Linecross	Inbred	Linecross	Inbred	Linecross
Cows bred to calve as 2-yr-olds	1	-	2	3	1	0
Calves born from 2-yr-olds						
Alive	1	-	2	1	0	0
Dead	0	-	0	1	0	0
Cows bred to calve at 3 yrs and up	10	11	14	9	8	1
Calves born from 3-yr-olds and up						
Alive	6	9	11	6	8	1
Dead	0	0	1	1	5	0
All calves born						
Alive	7	9	13	7	5	1
Dead	0	0	1	2	0	0
Total	7	9	14	9	5	1
Calves weaned	5	7	13	7	5	1
Percent calf crop						
Birth	64	82	93	75	56	100
Weaning	45	64	87	58	56	100

Calf Data (By line of calf's sire)

	Bulls		Heifers		Bulls		Heifers		Bulls		Heifers	
	No.	Ave.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
INBREDS												
Weaning age	2	208	3	196	4	179	8	203	2	211	2	190
Weaning weight		282		343		350		419		370		285
Adj. weaning wt. 200 days		332		396		447		470		404		343
Weaning score:												
Conf.		4.0		4.7		4.2		4.8		5.0		4.2
Inbreed. of calf		.43		.28		.38		.32		.44		.29
Inbreed. of dam		.30		.25		.25		.24		.36		.18
LINECROSSES												
Weaning age		-		-	5	195	6	209	5	224	7	208
Weaning weight		-		-		390		442		422		360
Adj. weaning wt. 200 days		-		-		390		466		400		382
Weaning score:												
Conf.		-		-		4.7		5.0		4.7		4.9

Colorado Agricultural Experiment Station

Cow Production Data (By line of dam's sire) 1963 calving

Breed	Hereford					
Line	Real Prince x Don		Rover		Royal	
	Inbred	Linecross	Inbred	Linecross	Inbred	Linecross
Cows bred to calve as 2-yr-olds	-	-	-	-	0	1
Calves born from 2-yr-olds						
Alive	-	-	-	-	-	-
Dead	-	-	-	-	0	0
Cows bred to calve at 3 yrs and up	-	-	-	9	6	13
Calves born from 3-yr-olds and up	-					
Alive	-	-	-	9	6	12
Dead	-	-	-	0	0	1
All calves born						
Alive	-	-	-	9	6	12
Dead	-	-	-	0	0	1
Total	-	-	-	9	6	13
Calves weaned	-	-	-	9	6	12
Percent calf crop						
Birth	-	-	-	100	100	93
Weaning	-	-	-	100	100	86

Calf Data (By line of calf's sire)

	Bulls		Heifers		Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
INBREDS												
Weaning age		-		-		-		-	5	185		-
Weaning weight		-		-		-		-		357		-
Adj. weaning wt. 200 days		-		-		-		-		438		-
Weaning score:												
Conf.		-		-		-		-		4.4		-
Inbreed. of calf		-		-		-		-		.52		-
Inbreed. of dam		-		-		-		-		.44		-
LINECROSSES												
Weaning age	7	215	4	217		-		-	12	179	12	181
Weaning weight		441		416		-		-		366		362
Adj. weaning wt. 200 days		443		434		-		-		422		432
Weaning score:												
Conf.		4.8		4.7		-		-		4.5		4.8

Colorado Agricultural Experiment Station

Cow Production Data (By line of dam's sire) 1963 calving

Breed	Hereford					
Line	Royal x Brae Arden Inbred	Royal x Brae Arden Linecross	San Juan Inbred	San Juan Linecross	Tarrington Inbred	Tarrington Linecross
Cows bred to calve as 2-yr-olds	-	-	1	1	1	-
Calves born from 2-yr-olds						
Alive	-	-	1	0	1	-
Dead	-	-	0	0	0	-
Cows bred to calve at 3 yrs and up	-	-	16	10	11	20
Calves born from 3-yr-olds and up						
Alive	-	-	11	8	11	19
Dead	-	-	0	0	0	0
All calves born						
Alive	-	-	12	8	12	19
Dead	-	-	0	0	0	0
Total	-	-	12	8	12	19
Calves weaned	-	-	11	8	12	19
Percent calf crop						
Birth	-	-	70	73	100	95
Weaning	-	-	65	73	100	95

Calf Data (By line of calf's sire)

	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.
INBREDS												
Weaning age		-		-	2	192	7	211	6	197	6	199
Weaning weight		-		-		378		389		431		408
Adj. weaning wt. 200 days		-		-		468		438		491		463
Weaning score:												
Conf.		-		-		4.6		4.7		4.8		5.2
Inbreed. of calf		-		-		.34		.32		.32		.28
Inbreed. of dam		-		-		.36		.26		.17		.16
LINECROSSES												
Weaning age		-	5	194	8	212	10	213	2	208	4	217
Weaning weight		-		399		475		405		480		441
Adj. weaning wt. 200 days		-		433		395		425		474		590
Weaning score:												
Conf.		-		4.8		5.3		5.0		5.2		5.0

Colorado Agricultural Experiment Station

Feedlot Performance Date: May 11, 1964

Breed	Hereford	Red Angus	Hereford x Shorthorn-Angus
Sex	Bulls	Bulls	Bulls
Number on test	91	2	4
Average:			
Age on test	-	-	-
Initial weight	453	611	589
Initial score:			
Cond.	-	-	-
Conf.	-	-	-
Days on test	140	140	140
Average gain	378	383	395
Average daily gain	2.70	2.73	2.82
Efficiency of feed utilization feed/100 lbs. gain	736	705	695
Lbs. gain/100 lbs. TDN	-	-	-
Final weight	831	994	984
Final score:			
Cond.	-	-	-
Conf.	4.7	5.1	5.3

A further 100 yearling bulls have been wintered on a growing ration since Dec. 24, 1963, and will be placed on a 140-day gain test on June 1, 1964.

Young Animals on Feed

Purebred Date: May 11, 1964

	Hereford		Red Angus		Shorthorn	
	Number individually fed	Number group fed	Number individually fed	Number group fed	Number individually fed	Number group fed
Bulls	91	-	2	-	-	-
Heifers	-	-	-	-	-	-
Steers	-	-	-	-	-	-
Grades - Crossbred (H x Angus - Shorthorn)						
Bulls	4	-				
Heifers	-	-				
Steers	-	-				

UNIVERSITY OF HAWAII

I. Station: Hawaii Agricultural Experiment Station, Honolulu, Hawaii

II. Project title: The estimation of genetic and phenotypic parameters in populations of beef cattle in Hawaii and their use in selection programs

III. Personnel:

Experiment Station:
Estel H. Cobb, Isaac Iwanago, Kiyoichi Morita, Oliver Wayman, and Artemio A. Ovejera of the University of Hawaii and Robert Hunter and Carl Bredhoff of Hawaiian Ranch Company.

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done this year and summary of progress:

Weights and grades on the 1963 calf crop at 8 and 12 months of age showed an increase in weight and decrease in grade. This is a reversal of a long-time trend showing no increase in weight during the first four months post-weaning.

	Weight			Grade		
	Weaning	12 mos.	Diff.	Weaning	12 mos.	Diff.
Bulls	459	591	132	4.82	4.16	-0.66
Heifers	433	512	79	5.03	4.43	-0.60

Twenty-four of the yearling bulls were shipped to the University Livestock Farm on Oahu for performance testing and carcass evaluation. They will be raised on pasture to 650 pounds liveweight, at which time half of each of the four sire groups will be finished in the feedlot and the balance on pasture to a shrunk liveweight of 1000 pounds. Detailed slaughter data will be obtained on all animals.

Data on 103 steers from the 1959, 1960, and 1961 calf crops were analyzed for the effect of feeding system on performance and specific carcass characteristics. After reaching 650 pounds shrunk liveweight, steers were assigned to be finished on pasture or in feedlot in equal numbers from each sire group. Slaughter was at approximately 1000 pounds shrunk liveweight.

Feedlot steers had consistently higher slaughter and carcass grades than pasture steers with the differences highly significant within year groups. The differences were greatest in the 1961 steers with slaughter

and carcass grade differences of 4.06 ± 0.40 and 2.78 ± 0.46, respectively. A comparison of percent trimmed retail cuts was made with seven live and twelve carcass measurements and scores. Correlations among live animal scores were all highly significant. The highest and lowest degree of association were between conformation and length of body scores and between slaughter grade and depth of body score with correlation coefficients of 0.8315 and 0.3437, respectively.

Feedlot finishing resulted in significantly increased slaughter grade, carcass grade, width of shoulder, width of round and fat thickness and significantly decreased carcass length, loin length and specific gravity.

Percent of trimmed retail cuts was negatively correlated with all live measures and scores except slaughter weight which was positive. All correlations were highly significant except slaughter weight and round score. The best predictor of percent trimmed retail cuts was specific gravity of the carcass with a correlation coefficient of 0.7240 followed by weight of kidney fat with a correlation coefficient of -.6494, both highly significant. Area of L. dorsi muscle was a poor predictor of percent trimmed retail cuts with a nonsignificant correlation coefficient of 0.1775.

Holstein steers were studied as a source of beef. Six finished in the feedlot had comparable USDA Federal grades at a younger age and the same weight as Hereford steers fed out in the same manner. Seven pasture-finished Holstein steers took longer to reach the same weight. They graded nearly two USDA grades lower than Hereford steers finished on pasture to the same shrunk liveweight.

During the year, development of a beef cattle substation in the Waimea section of the island of Hawaii proceeded as fast as the available manpower permitted. The station is comprised of 195 acres in a high rainfall area with an anticipated carrying capacity in excess of one A.U. per acre and 200 acres of dryland (35 in./year) approximately 2.5 miles away. The latter will provide seasonal grazing. All peripheral fencing has been completed on the dryland pasture. The fences on the other property are adequate at present. The herdman's home and an all-purpose equipment and storage shed have been completed. A laboratory, storage and utility building is under construction. Stock corrals are being constructed.

VI. Application of findings:

Interest in record of performance and the benefits to be obtained thereby have increased. The data accumulating from carcass evaluation of sire groups under two feeding regimes are providing a base for more efficient selection of replacement animals and for more realistic USDA beef grades.

VII. Work planned for the future:

Continue collection of liveweights and conformation scores at weaning, 12 and 20 months of age and analysis of data for selection indices.

Compare production of Holstein and Hereford beef as to quality and economy of production under two feeding systems.

Complete development of Waimea Beef Cattle Substation and purchase foundation herd of 100 two-year-old heifers for intensive breeding studies.

VIII. Publications:

Mahmud, Anuwar. 1963. The estimates of heritability of weaning weight, preweaning gain, and conformation score of range beef cattle. M. S. Thesis. University of Hawaii. Honolulu.

Mahmud, Anuwar, and Estel H. Cobb. 1963. Factors affecting weaning weights, preweaning gains, and conformation scores of beef calves in Hawaii. (Abs. 24.) J. Anim. Sci. 22(3):820.

IX. PROJECT SUMMARY

Hawaii Agricultural Experiment Station

Cattle Inventory Date: June 1964

Breed	Hereford	
Line	Hawaiian Ranch Co.	Waimea
Station	Hawaii	Hawaii
Bulls (12 mos. or over)	121	
Cows (2 yrs. or over)	383	4
Heifers, yearlings	159	
Bull calves	181	
Heifer calves	169	
Percentage used for breeding project.	100	100
Estimated cash value	$328,250	$1,600

Cow Production Data

Breed	Hereford
Line	Kaalualu, Kapapala and Martin
Cows bred to calve at 3 yrs and up	399
Calves born from 3-yr-olds and up	
Alive	340
Dead	13
Calves weaned	315
Percent calf crop*	
Birth	85.2
Weaning	79.0

*Based on number of cows exposed to the bulls and the number of live calves.

	Bulls	Heifers
Number	153	162
Average weaning:		
Age, days	254.5	256.3
Weight, lbs.*	482.0	457.1
Adj. weight, 240 days, lbs.	458.7	432.6
Conformation score**	4.8	5.0

* Overnight shrink without feed or water.

** Based on a grading system where 9 is the highest and 1 is the lowest.

Hawaii Agricultural Experiment Station

Feedlot Performance Date: June 1964

Breed	Hereford			
Sire	87	87	417	417
Treatment	Feedlot	Pasture	Feedlot	Pasture
Number on test	2	3	3	3
Average:				
Age put on test	532.5	525.3	510.7	504.7
Initial weight	658.5	615.7	682.7	633.3
Days on test	196.5	359.7	137.7	310.3
Gain				
Total	365	387.6	334.3	366
Average daily gain	2.12	1.09	2.44	1.18
Final weight	1023.5	1003.3	1017.0	999.3
Final score:				
Condition (Slaughter grade)	22.0	17.0	20.7	16.3
Conformation	8.0	5.3	7.3	5.7

Breed	Hereford			
Sire	548	548	747	747
Treatment	Feedlot	Pasture	Feedlot	Pasture
Number on test	3	3	3	3
Average:				
Age put on test	516.0	508.3	519.0	513.0
Initial weight	683.7	649.0	675.0	624.0
Days on test	165.7	308.0	189.3	289.3
Gain				
Total	323.6	336.3	322.0	374.7
Average daily gain	2.07	1.11	1.77	1.30
Final weight	1007.3	985.3	997.0	998.7
Final score:				
Condition (Slaughter grade)	20.3	16.7	20.3	16.7
Conformation	6.7	5.3	6.3	5.3

Young Animals on Feed None

Land, Physical Facilities, and Equipment Used

Item	Number	Actual cash value	Percentage used for breeding project
Land (acres) Kaalualu	2070	$ 22,700	100 annual lease value
Corrals, chutes, & scales	1 set	5,000	100
Portable scale	1	650	80
Land (acres) Waimea	395	197,500	Not in use
Buildings (Herdsman's home, machine & repair bldg., Lab utility bldg., corrals, livestock scale, service station)		Total value not yet determined	
University of Hawaii			
Pasture (acres) irrigated	12.5	12,500	100
Portable scale	1	650	50
Corrals, chutes, scale, and barn	1 set	10,000	90
Meat laboratory	1	80,000	75
Working horse	1	250	80
Irrigation system	1	15,000	60
Profilometer	1	200	100
Leica camera set	1	613	50
Electronic ejaculator	1	544	100
Monroe adding machine	1	238	65
Monroe calculator	1	1,014	100
Friden calculators	2	2,102	80
IBM electric typewriter	1	270	20
Stenorette dictating machine	1 set	485	100
Air conditioner	1	230	100
Wiley laboratory mill	1	275	90
RCA refrigerator	1	350	50
Power chain saw	1	160	75
Toledo scales	2	1,168	75
Miscellaneous equipment		2,036	100
Total value		$156,435	

UNIVERSITY OF IDAHO

I. Station: Idaho Agricultural Experiment Station, Moscow, Idaho

II. Project title: The improvement of economically important traits in beef cattle with special emphasis on fertility and carcass quality

III. Personnel:

Experiment Station:
R. E. Christian, L. E. Orme, T. D. Bell, C. W. Hodgson, and S. E. Slyter

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, Coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done this year and summary of progress:

Eighteen bull calves (12 Hereford, 3 Shorthorn, and 3 Angus) were individually fed for 140 days following weaning to obtain feedlot gain and feed efficiency. The average rate of daily gain for the Herefords was 2.00 pounds, for the Shorthorns 1.82 pounds, and for the Angus 1.68 pounds. The Hereford bulls required 421.6 pounds TDN per 100 pounds gain, the Shorthorn bulls required 479.4 pounds, and the Angus bulls required 522.9 pounds.

A study comparing various methods of adjusting weaning weights of beef calves was completed this year. Weaning weight records on a total of 261 Hereford calves, 129 Shorthorn calves, and 109 Angus calves were used in the study. Fifteen different methods of adjusting weaning weight were compared (table 1).

To compare the relative accuracy of the various methods of computing adjustment factors, all methods were compared with the least-squares method of adjusting weaning weights (table 4).

The correlations between least-squares adjusted weaning weight and weaning weights adjusted by methods 12, 13, 14, and 15 were, in general, higher than for other methods. This is probably due to the small age subclass numbers within years.

Many breeders cooperating in the Idaho production testing program do not know the ages of the cows in their herds and as a result are using essentially method 5 for adjusting weaning weights in their herds. The present study indicates that including age of dam corrections (method 12) would increase the accuracy of their corrections, particularly

Table 1.--Methods Used to Adjust Weaning Weights

Method[a] number	Age at weaning	Sex of calf	Age of dam
3	Nomograph	None	None
4	Daily gain (nomograph)	None	None
5	Nomograph	Nomograph (within years)	None
6	Daily gain (nomograph)	Additive (within years)	None
7[b]	Nomograph	Nomograph	Searle's[c]
8[b]	Nomograph	Searle's	Searle's
9[b]	Daily gain (nomograph)	Searle's	Searle's
10[b]	Daily gain (nomograph)	Additive	Additive
11[d]	Least squares	Least squares	Least squares
12[d]	Nomograph	Nomograph	Searle's
13[d]	Nomograph	Searle's	Searle's
14[d]	Daily gain (nomograph)	Searle's	Searle's
15[d]	Daily gain (nomograph)	Additive	Additive

[a]Methods numbers 1 and 2 were birth weight and actual weaning weight
[b]Correlations made within years
[c]Searle, S. R. 1960. J. Dairy Sci. 43:821-824.
[d]Corrections made over all years.

Table 2.--Least Squares Constants for Weaning Weights

	Hereford	Shorthorn	Angus
Age of dam:			
2 and 3	-22.7	-33.0	-6.6
4	-6.8	-3.0	3.8
5	10.7	-5.1	12.6
6	15.7	-2.1	14.8
7	7.2	14.7	-.4
8	16.6	15.5	-.9
9	3.9	13.1	-23.4
10[a]	-2.7	None	None
11 and up	-21.9	None	None
Sex:			
Males	13.6	21.6	26.2
Females	-13.6	-21.6	-26.2
Calf age regression	1.878	1.802	1.417

[a]Shorthorn and Angus cows over 9 years of age are included in the 9-year group because of small numbers

Table 3.--Searle's Age of Dam and Sex Adjustment for Weaning Weight Over All Years (Method 13)

	Hereford	Shorthorn	Angus
Age of dam:			
3	52	60	19
4	25	14	12
5	3	12	0
6	0	0	0
7	5	6	9
8	0	0	0
9	19	6	32
10[a]	23	--	--
11	43	--	--

[a]Shorthorn and Angus cows over 9 years of age are included in the 9-year group

Table 4.--Correlations between Weaning Weights Obtained by Various Methods of Adjustment and Least Squares Method

Method of adjustment	Hereford	Shorthorn	Angus
1	0.15	0.41	0.37
2	.68	.59	.73
3	.73	.73	.83
4	.71	.73	.84
5	.78	.81	.90
6	.75	.69	.90
7	.71	.81	.84
8	.69	.73	.84
9	.68	.70	.84
10	.53	.69	.72
12	.88	.86	.93
13	.89	.89	.94
14	.85	.87	.92
15	.85	.86	.92

in the Hereford breed. On the basis of the present study, it is recommended that breeders use either method 12 or 13 in their herds.

Four additional Hereford bulls from the University of Idaho herd have been leased to one cooperating cattleman. These bulls are being used for breeding this year and calves will become available next year for feedlot testing.

At the present time, steer offspring of four pairs of leased bulls are on feed in a cooperating feedlot in southeastern Idaho. These calves will be slaughtered in June.

VI. Application of findings:

Any method of adjusting weaning weights of beef calves which involves correcting for age at weaning will improve the accuracy of selection of replacement animals. Including an age-of-dam correction and a sex correction will increase the accuracy of weaning weight adjustments.

It is recommended that beef cattle breeders use method 12, which involves the nomograph correction for age at weaning and sex of calf and Searle's correction for age of dam.

Since the nomograph corrections assume a 70-pound birth weight, method 14 would be more accurate if average birth weights deviated much from 70 pounds.

VII. Work planned for the future:

The study on heritabilities of production traits and genetic correlations among these traits will be finished this year. Steer calves from University bulls that have been leased to cooperating ranchers will be slaughtered and carcass data obtained. Additional steer calves will be available from other cooperating ranches this fall.

VIII. Publications:;

Mitchell, Ladd A. 1963. A study of some methods of standardizing weaning weights in beef cattle. M. S. Thesis. University of Idaho. Moscow.

IX. PROJECT SUMMARY

Idaho Agricultural Experiment Station

Cattle Inventory
Purebred

June 1964

	Hereford	Shorthorn	Angus
Station	Main	Main	Main
Bulls (12 mo. or over)	19	5	7
Cows (2 yr. or over)	67	29	24
Heifers, yearlings	8	4	5
Bull calves	23	7	10
Heifer calves	21	10	7
Percentage used for breeding project	50	50	50
Estimated cash value	$40,350	$15,400	$16,500

Cow Production Data

	Hereford	Shorthorn	Angus
Cows bred to calve as 2-yr.olds	0	0	0
Cows bred to calve at 3 yrs. and up	56	24	20
Calves born:			
Alive	47	18	19
Dead	0	0	0
Total	47	18	19
Calves weaned	44	17	16
Percent calf crop (of cows bred)			
Birth	83.9	75.0	95.0
Weaned	78.6	70.8	80.0

	Hereford Bulls No.	Hereford Bulls Av.	Hereford Heifers No.	Hereford Heifers Av.	Shorthorn Bulls No.	Shorthorn Bulls Av.	Shorthorn Heifers No.	Shorthorn Heifers Av.	Angus Bulls No.	Angus Bulls Av.	Angus Heifers No.	Angus Heifers Av.
Average:												
Birth weight	23	68.4	24	65.7	8	69.0	10	62.4	10	70.9	9	65.6
Weaning age		179.0		185.1		153.0		181.4		186.7		190.7
Weaning weight	23	408.6	21	395.0	7	343.9	10	360.5	10	413.8	6	399.5
Adj. weaning wt.-200 days		441.6		452.4		417.7		422.7		437.1		447.2
Weaning score:												
Conformation	23	11.3	21	11.7	7	11.3	10	12.0	10	11.8	6	10.4

Idaho Agricultural Experiment Station

Feedlot Performance

	Hereford	Shorthorn	Angus
Line	--	--	--
Sex	Bull	Bull	Bull
Number on test	12	3	3
Average:			
Age on test	236.8	238.3	244.3
Initial weight	424.3	427.0	477.7
Initial score:			
Conformation	11.8	12.0	12.3
Days on test	140	140	140
Gain - total	280.2	254.3	235.7
Average daily gain	2.00	1.82	1.68
Efficiency of feed utiliza-tion-lb.TDN/100 lb. gain	421.6	479.4	522.9
Final weight	704.5	681.3	713.3
Final score:			
Conformation	10.8	11.3	12.0

Young Animals on Feed

	Hereford		Shorthorn		Angus	
	Number individu-fed	Number group fed	Number individu-fed	Number group fed	Number individu-fed	Number group fed
Bulls	12	3	3	0	3	2
Heifers		24		10		6
Steers		8		4		5

MONTANA STATE COLLEGE

I. Montana Agricultural Experiment Station, Bozeman, and the North Montana Branch Station, Havre, Montana

II. Project title: Recurrent selection and record of performance selection in open and closed beef cattle herds. W-1,M.S. 873, A.I. 104, North Montana Branch Station 71.

A. 1. The establishment of inbred lines of registered Hereford cattle, both horned and polled, that will result in improvement in such characteristics as rate and economy of gain, fertility, nursing ability, longevity, and carcass quality.

2. Maintain an outbred herd of Herefords with bulls selected and furnished by the purebred breeders. The bulls are to be primarily good, high scoring individuals according to breed association standards.

B. Establishment of an improved herd of registered Angus cattle in which the males are selected on a high level of performance as indicated by standard record of performance procecures.

C. Investigate feasibility of breeding for specific combining ability through recurrent selection.

III. Personnel:

Experiment Stations:
Bozeman: F. S. Willson, Alva E. Flower, J. R. Dynes, and R. W. Miller and N. A. Jacobsen, Consultants
Havre: Lanny D. Baumann, and Claude Windecker, Consultant

U. S. Department of Agriculture, Agricultural Research Service, Miles City, Montana;
N. M. Kieffer, Superintendent, U. S. Range Livestock Experiment Station

Denver, Colorado:
R. T. Clark, Coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done this year and summary of progress:

We continued with our two-sire line of Hereford cattle and this past year distributed what few cows there were from the previous Visual study between the two ROP sires. These animals and their descendants will not be considered in the project from now on except incidentally.

In the Angus herd, we used one of our own top indexed two-year-old bulls and a top indexed sire out of the herd of Al Mattson of Bickleford, Washington. He was owned by the American Breeders Service. We made an attempt this past year to get some topcross tests on our Angus bulls with private cooperators. We placed two bulls, but the third bull was not placed because the man who was to cooperate withdrew at the last minute. However, of the two that started out with our bulls, only one will have authentic records since the other man's cattle got mixed up during the breeding season. The progeny from these bulls will be brought into Bozeman and fed out in the feedlot with carcass tests comparing indexed bulls with the rancher's own bulls as valid mating records become available.

We indexed 10 ROP Hereford bulls and 4 from the Visually selected herd and we had indexed 10 heifers from the ROP herd and 2 from the original Visual herd. We indexed 14 Angus ROP bulls and 14 Angus ROP heifers (see table on feedlot performance).

Havre crossline heifers were full fed during the 1962-63 year. Carcasses of slaughter animals continue to be studied as in past years. Additionally, one-third of carcasses from each sire group were given fat-lean-bone separation studies.

Table 1 shows a three-year summary of some production and carcass traits involving steer calves only. Previous observations showing that there was a trend for faster gaining cattle to grade lower do not show in this summary when all crosslines are compared to the Miles City controls. This could be a bull effect as the Miles City Control progeny are from the same sire in 1962 and 1963. The faster gaining and lower grade effect does show a trend in the Rancher and Rancher-Havre line top crosses.

Estimated lean yield using the formula of Murphy (1960) shows the Rancher $\times$ Rancher steers slightly excel all the crossline steers except HL_1.

Havre Line 2 crossline steers with the highest average daily gain of all the crosslines are inferior to the others in estimated lean yield and in other characteristics of quality as measured by our present standards.

Publications by Flower and co-workers summarize progress in the Havre lines. Selection pressure, while appreciable in mass selection, has been negligible in the recurrent phase.

VI. Application of findings:

The Montana Beef Performance Association continues to grow at a rapid pace. They now have 257 active members and 36 associate members, which is about a 50 percent increase over the previous year. They also had over 9,500 head of calves in their commercially certified calf program, which is a 20 percent increase over last year. There were two bull

Table 1.--Three-Year Summary of Means of Some Production and Carcass Traits of Hereford Steers

Havre 1961-63

	Steers	Carcass weight	Average daily gain	Fat thickness	Rib eye area	Rib eye per 100# carcass	Grade Choice	Grade Good	Estimated lean yield
	number	pounds	pounds	cm.	sq. in.	sq. in.	percent	percent	percent
Miles City Controls	27	610	2.42	17.2	11.49	1.88	77.8	22.2	48.85
HL_1 × MC	26	598	2.35	16.8	11.23	1.88	69.2	26.9[a]	48.88
HL_2 × MC	29	590	2.40	19.3	10.58	1.79	51.7	48.3	47.90
HL_3 × MC	23	596	2.38	20.8	11.75	1.97	78.3	21.7	48.36
All Crosslines	78	595	2.34	19.0	11.19	1.88	65.4	33.3[a]	48.36
Rancher × Rancher	47	576	2.18	18.9	11.18	1.94	80.8	19.2	48.59
HL top × Rancher	48	598	2.27	17.8	11.61	1.94	68.8	31.2	48.93

[a]There was one Standard grade carcass so these do not total 100 percent.

indexing centers besides their private cooperators in their indexing programs. The Stanford indexing center, the largest in the country, fed over 300 bulls this past year and the one at Billings fed 180 bulls. The Association also has 3,400 purebreds in their program.

Crossline Havre cattle are continuing to give a good account of themselves and will, therefore, indirectly promote rotation and other crossline production among commercial cattlemen.

VII. Work planned for the future:

We have three cooperators lined up in three counties and have placed three Angus two-year-old bulls with these cooperators. This will give us a comparison between our indexed bulls on rancher cattle versus rancher bulls on rancher cattle. We plan to carry these through feedlot tests and carcass evaluations.

We plan to investigate opportunity for progeny testing of sires in our various herds and lines through artificial insemination firms and associations already in existence. This is for purposes of 1) evaluating our lines more widely for top-crossing merit, and 2) uncovering outstanding sires.

We plan on cooperating with the Arizona station in top-cross testing of our ROP Hereford line starting in the fall of 1964.

Mass recurrent selection will continue at Havre. Age of heifer at puberty will be observed and tabulated by lines. Effort will be concentrated on recording recent years' data as well as computing and recording inbreeding coefficients. To this end, an additional graduate assistantship is being implemented.

Preliminary indications at Havre that opportunity existed for recurrent selection before extensive pressure was applied in mass selection for growth characteristics, but was largely lost or swamped thereafter, may be investigated with laboratory animals at Bozeman. In this connection a review of the literature will be undertaken to determine if such study already has been made.

VIII. Publications:

Flower, A. E., J. S. Brinks, J. J. Urick, and F. S. Willson. 1963. Comparisons of inbred lines and linecrosses for performance traits in Hereford range cattle. J. Anim. Sci. 22(4):914-918.

Willson, F. S. 1963. North Montana Branch Station's contribution to beef cattle research. North Montana Beef Prod. School. Proc. November.

IX. PROJECT SUMMARY

Montana Agricultural Experiment Station

Cattle Inventory - Bozeman
Purebred

June 1, 1964

	Hereford	Hereford	Angus
Line	ROP	Visual[a]	ROP
Station	Bozeman	Bozeman	Bozeman
Bulls (12 mo. or over)	16[b]	5[c]	18
Cows (2 yr. or over)	39[d]	14	50
Heifers, yearlings	10	2	13
Bull calves	19	5	20
Heifer calves	18	5	20
Percentage used for breeding project	60	60	60
Estimated cash value	$27,100	$8,300	$31,050

[a]Visual Herefords are maintained for classroom work and are not involved in the W-1 project.
[b]Four bulls at Red Bluff
[c]One bull at Red Bluff
[d]One cow at Red Bluff

Feedlot Performance

	Hereford	Hereford	Hereford	Hereford	Angus	Angus
Line	ROP	ROP	Visual[a]	Visual	ROP	ROP
Sex	Bulls	Heifers	bulls	Heifers	Bulls	Bulls
Number on test	10	10	4	2	14	14
Average:						
Age on test	201	210	201	213	212	211
Initial weight	435	405	443	412	472	470
Initial score						
Conformation	79	79	82	81	80	81
Days on test	140	140	140	140	140	140
Total gain	278	262	270	238	278	252
Av. daily gain	1.98	1.87	1.93	1.67	1.98	1.80
Efficiency:						
Lb.TDN/100# ga.	776.7		796.5		931.7	
Final weight	713	667	713	650	750	722
Final score:						
Conformation	78	78	80	81	78	78

[a]Visual Herefords are maintained for classroom work and are not involved in the W-1 project

Cow Production Data - Bozeman

	Hereford	Hereford
Line	ROP	Visual[a]
Cows bred to calve as 2-year-olds	9	1
Calves born from 2-year-olds		
Alive	6	0
Dead	3[c]	1
Cows bred to calve at 3 years and up	29	16
Calves born from 3-yr.-olds and up		13
Alive	28	13
Dead	1[c]	3[c]
All calves born		
Alive	34	13
Dead	4	4
Total	38	17
Calves weaned	30	13
Percent calf crop[b]		
Birth	87.62	76.47
Weaning	78.95	76.47

	Bulls		Heifers		Bulls		Heifers		Steers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:										
Birth weight	10	88	10	73.8	4	78.25	2	74.5	13	77
Weaning age		182.8		191.0		183.25		195		181.5
Weaning wt.	10	426.9	10	384.4	4	436.7	2	390	13	369
Adj. weaning wt.-180 days		422.6	10	365.4	4	434	2	362.5	13	361
Weaning score:										
Conformation		79		79		82		81		75

[a]Visual Herefords are maintained for classroom work and are not involved in the W-1 Project
[b]Cows bred divided into calves born and calves weaned
[c]Cows aborted calves

Cow Production Data - Bozeman

	Angus					
Line	ROP					
Cows bred to calve as 2-yr.-olds	11					
Calves born from 2-yr.-olds						
Alive	11					
Dead	0					
Cows bred to calve at 3 yrs. and up	31					
Calves born from 3-yr.-olds and up						
Alive	30					
Dead	1[a]					
All calves born						
Alive	41					
Dead	1					
Total	42					
Calves weaned	39					
Percent calf crop[b]						
Birth	97.6					
Weaning	92.8					
	Bulls		Heifers		Steers	
	No.	Av.	No.	Av.	No.	Av.
Average:						
Birth weight	14	68	14	63	3	71
Weaning age		190		193		156
Weaning weight	14	447	14	437	3	336
Adj. weaning wt.-180-days	14	424	14	409.7	3	378
Weaning score:						
Con formation		80		81		72

[a]Cow aborted calf

[b]Cows bred divided into calves born and calves weaned

Young Animals on Feed - Bozeman
Purebred

	Number individually fed	Number group fed	Number individually fed	Number group fed
Bulls	14		14	
Heifers		12		14
Steers		13		3

Land, Physical Facilities, and Equipment Used

	Number	Actual cash value	Percent used for breeding project
Beef barn and corrals	1	$18,500	60
Sheds	5	6,300	60
Irrigated land	200 acres	80,000	100
Saddle horses	2	300	60
Miscellaneous equipment		105,800	

Cattle Inventory - Havre

Purebred

	Hereford	Hereford	Hereford	Hereford
Line	Line 1	Line 2	Line 3	Line 4
Station	Havre	Havre	Havre	Havre
Bulls (12 mo. or over)	11	14	10	1
Cows (2 yr. or over)	31	35	25	40
Heifers, yearlings	8	9	8	0
Bull calves	13	12	7	15
Heifer calves	6	13	8	16
Percent used for breeding project	100	100	100	100
Estimated cash value	$13,850	$16,600	$11,500	$10,050

Grade

	Hereford	Hereford
Line	MC L1 Control	Crossline (Heifers)
Station	Havre	Havre
Bulls (12 mo. or over)	0	0
Cows (2 yr. or over)	83	0
Yearling heifers	9	0
Steer calves	31	26
Heifer calves	33	0
Percent used for breeding project	100	100
Estimated cash value	$21,150	$3,250

North Montana Branch Station

Cow Production Data - Havre

	Hereford (Polled)		Hereford		Hereford	
Line	Havre Line 1		Havre Line 2		Havre Line 3	
Cows bred to calve as 2-yr.-olds	6		8		4	
Calves born from 2-yr.-olds						
Alive	4		1		2	
Dead	--		2		0	
Cows bred to calve at 3 yrs. and up	23		25		17	
Calves born from 3-yr.-olds and up						
Alive	19		20		15	
Dead	1		2		--	
All calves born						
Alive	23		21		17	
Dead	1		4		0	
Total	24		25		17	
Calves weaned	23		20		15	
Percent calf crop[a]						
Birth	82.8		66.7		81.0	
Weaning	82.8		60.6		71.4	
	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers
	No. Av.	No. Av.	No. Av.	No. Av.	No. Av.	No. Av.
Average:						
Birth weight	15 76	8 70	12 84	8 80	5 74	9 72
Weaning age	176	183	172	180	179	185
Weaning weight	392	386	378	384	409	385
Adj. Weaning wt.-180 days	399	391	391	384	409	377
Weaning score:						
Conformation						

[a]Percent calf crop calculated on basis of $\frac{\text{calves weaned}}{\text{cows exposed}}$

North Montana Branch Station

Cow Production Data - Havre

	Hereford	Hereford
Line	MC L1 Control	Test Herd No. 24
Cows bred to calve as 2-yr.-olds	0	2
Calves born from 2-yr.-olds		
Alive	0	1
Dead	0	1
Cows bred to calve at 3 yr. and up	28	10
Calves born from 3-yr.-olds and up		
Alive	26	8
Dead	0	0
All calves born		
Alive	26	9
Dead	0	1
Total	26	10
Calves weaned	26	9
Percent calf crop[a]		
Birth	92.9	75.0
Weaning	92.9	75.0

	Steers		Heifers		Steers		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	17	91	9	90	5	87	4	85
Weaning age		181		187		172		178
Weaning weight	17	468	9	484	5	405	4	419
Adj. weaning wt.-180 days		462		470		419		412
Weaning score:								
Conformation								

[a]Percent calf crop calculated on $\frac{\text{calves born or weaned}}{\text{cows exposed}}$

North Montana Branch Station

Cow Production Data - Havre

	Hereford		Hereford		Hereford	
Line	Test herd HL1 38		Test herd HL2 924		Test herd HL2 930	
Cows bred to calve as 2-yr.olds	2		2		2	
Calves born from 2-yr.-olds						
Alive	1		2		2	
Dead	0		--		0	
Cows bred to calve at 3 yrs. and up	10		10		10	
Calves born from 3-yr.-olds and up						
Alive	9		8		10	
Dead	1		0		0	
All calves born						
Alive	10		10		12	
Dead	1		0		0	
Total	11		10		12	
Calves weaned	10		9		12	
Percent calf crop[a]						
Birth	83.3		83.3		100	
Weaning	83.3		75.0		100	
	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers
	No. Av.	No. Av.	No. Av.	No. Av.	No. Av.	No. Av.
Average:						
Birth weight	5 82	6 78	6 91	4 91	8 82	4 83
Weaning age	170	186	175	172	174	168
Weaning weight	398	444	424	413	394	370
Adj. weaning wt.--180 days	409	431	432	421	405	385
Weaning score:						
Condition						

[a]Percent calf crop calculated on basis of $\frac{\text{calves weaned}}{\text{cows exposed}}$

North Montana Branch Station

Cow Production Data - Havre

Line	Hereford Test herd HL3 967				Hereford Test herd HL3 39			
Cows bred to calve as 2-yr.-olds	2				2			
Calves born from 2-yr.-olds								
Alive	1				2			
Dead	0				0			
Cows bred to calve at 3 yr. and up	9				10			
Calves born from 3-yr.-olds and up								
Alive	8				10			
Dead	0				0			
All calves born								
Alive	9				12			
Dead	0				0			
Total	9				12			
Calves weaned	9				12			
Percent calf crop[a]								
Birth	81.8				100.0			
Weaning	81.8				100.0			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	6	86	3	81	9	82	3	75
Weaning age	169		187		176		180	
Weaning weight	388		391		458		400	
Adj. weaning wt.--180 days	405		379		465		400	
Weaning score:								
Conformation								
Condition								

[a]Percent calf crop calculated on basis of $\frac{\text{calves born or weaned}}{\text{cows exposed}}$

Feedlot Performance - Havre

	Hereford MC L1	Hereford H L5	Hereford H L5	Hereford H L5	Hereford H L6	Hereford H L6	Hereford H L6	Hereford H L6	Hereford H L7
Line	Control	H L1 903	H L1 942	H L1 942	H L2 924	H L2 924	H L2 930	H L2 930	H L3 967
Sex	Steers	Steers	Steers	Heifers	Steers	Heifers	Steers	Heifers	Heifers
Number on test	10	6	2	3	4	2	1	4	2
Initial weight	438	457	456	415	402	384	342	391	428
Days on test	260	247	238	254	264	266	280	259	252
Gain - total	622	597	599	503	648	606	668	568	610
Avg. daily gain	2.39	2.42	2.52	1.98	2.45	2.28	2.38	2.19	2.42
Final weight	1060	1054	1055	918	1050	990	1010	959	1038
Final score:									
Condition	9 Choice 1 Good	4 Choice 2 Good	2 Choice	3 Choice	3 Choice 1 Good	2 Choice	1 Choice	1 Prime 3 Good	2 Choice

	Hereford	Hereford	Hereford	Hereford	Hereford	Hereford	Hereford	Hereford
	Crossline	Crossline	R.G. 111	R.G. 111	R.G. 5	R.G. 5	R.G. VII	R.G. VII
Line	MSC 005	MSC 005	R.G. 111	H L3	R.G. 5	H L2	R.G. VII	H L2
Sex	Steers	Heifers	Steers	Steers	Steers	Steers	Steers	Steers
Number on test	4	3	7	6	6	6	6	6
Initial weight	450	407	413	415	415	379	379	392
Days on test	231	243	275	277	277	274	268	281
Gain - total	575	516	601	621	576	672	626	635
Average daily gain	2.49	2.12	2.19	2.24	2.08	2.45	2.34	2.26
Final weight	1026	923	1014	1036	991	1051	1005	1027
Final score:								
Condition	3 Choice 1 Good	3 Choice	7 Choice	5 Choice 1 Good	5 Choice 1 Good	5 Choice 1 Good	5 Choice 1 Good	5 Choice 1 Good

North Montana Branch Station

Young Animals on Feed 1963-64 - Havre

Purebred	Hereford	
	Number individually fed	Number group fed
Bulls	29	
Heifers		27
Grade		
Heifers	33	
Steers		91

Land, Physical Facilities, and Equipment Used - Havre

	Number	Actual cash value	Percent used for breeding project
Bull barn	1	$15,750	75
Long shed	1	13,750	90
Home pasture	1,780 ac.	25,830	90
Home farm land	200 ac.	5,400	85
Leased pasture	5,000 ac.	49,500	100
A.I. truck	1	1,530	75
Saddle horses	8	720	90
Scale and weigh house (sta.)	1	1,710	90
Scale and weigh house (lease)	1	630	100
Corrals--home station		2,700	90
Corrals--lease		1,350	100
Cattle squeeze	2	360	100
Cabins--lease	2	1,800	100
Automatic waterers	5	450	90

U. S. RANGE LIVESTOCK EXPERIMENT STATION

I. Station: U. S. Range Livestock Experiment Station, Miles City, Montana

II. Project titles:

AH d1-1 (Rev. 2.) Breed crossing for increased production in beef cattle

AH d1-2 (Rev. 2.) Development of superior lines of beef cattle

AH d1-41 A study of response to selection and genetic-environmental interaction in genetically similar groups of Hereford cattle at two locations

III. Personnel:

U. S. Range Livestock Experiment Station, Miles City, Montana:
Nat M. Kieffer and J. J. Urick

Montana State College, Bozeman, Montana:
F. S. Willson and A. E. Flower

Office of Coordinator, Denver, Colorado:
R. T. Clark, Coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done this year, and summary of progress:

Project AH d1-1 (Rev. 2.) Breed crossing for increased beef production

The first calves from the breed crossing project were dropped in 1962. All the males were castrated except two of each breed or breed cross that were saved for the Physiology Puberty Study. The remaining steers and heifers were weaned the third week in October at an average age of approximately 190 days. The steers were placed in a feedlot and group fed a standard fattening ration and were marketed in May, June, and July 1963 as they reached a weight of approximately 1,000 to 1,050 pounds (off feed). They were slaughtered at Billings, Montana, where carcass data were obtained. Table 1 shows the birth weight, weaning weight, postweaning gains, and slaughter and carcass grades of the steers. Table 2 shows the birth weight, weaning weight, and 18-month weight (off grass) of contemporary straightbred and crossbred heifers.

Lines 11, 12, and 14, newly formed Hereford lines from crossing other inbred lines on the station, are being continued as two-sire lines. Selection in these lines is based largely on weaning weight, gain on test, and conformation score. The level of inbreeding in these lines is relatively low.

Table 1. Summary of Straightbred and Contemporary Crossbred Record of Performance Steers - 1962-63

Breed group	No. head	Birth wt.	Wean. wt.	Age at wn.	Final wt.	Gain on feed	Days on test	Avg. daily gain	Sales wt.	Sl.[a] grade	Carc.[a] grade
		lb.	lb.	da.	lb.	lb.	da.	lb.	lb.		
Hereford	5	80	415	189	996	591	257	2.30	922	11.2	14.0
Angus	8	75	437	194	993	555	256	2.17	909	10.3	10.3
Charolais	6	92	485	191	1020	535	213	2.51	954	16.3	15.0
H × A	6	74	465	193	990	528	230	2.29	921	12.7	11.7
A × H	4	80	449	189	1018	570	223	2.56	945	11.0	10.0
H × C	4	81	522	196	1032	527	217	2.42	951	14.0	16.5
C × H	2	100	519	188	1033	516	189	2.73	970	13.0	13.0
A × C	2	77	458	193	1006	556	256	2.17	930	12.0	10.0
C × A	4	98	511	189	1019	517	198	2.61	947	15.5	15.5
H × BS	3	90	505	167	1011	529	202	2.61	947	17.3	12.7
A × BS	7	87	517	189	1013	497	220	2.26	938	15.4	10.3
C × BS	5	106	543	190	1015	482	197	2.45	951	18.8	16.0

[a]Slaughter and carcass grades as follows: Low Good = 18, Medium Good = 16, High Good = 14, Low Choice = 12, Medium Choice = 10.

The Hereford inbred Lines 1, 4, 6, 9, and 10 in the line crossing project have had their third calf crop this year. Tables 3 and 4 show the performance of the bull calves from the various inbred sires on the breeding herds of cows during the years 1962-63 and 1963-64.

When evaluating the Record of Performance of the bull calves for the first two years of the crossline matings up through 1964, those by the Line 4 sires excelled the ones by the other lines of sires. The bulls by the Line 1 and Line 10 sires compared favorably with the ones by the Line 4 sires. During both Record of Performance trials the bulls by the Line 6 and Line 9 sires made the poorest performance record when compared with the other lines of sires. During the 1963-64 year the crossline bulls weaned 22 pounds heavier (on the basis of the 180-day weights) than the straightline bulls. In feedlot performance the crossline bulls gained 2.76 pounds per day as compared to 2.64 pounds per day for the straightline bulls. The crossline heifers weaned 28 pounds heavier than the straightline heifers. This advantage compares closely with that of the 1962-63 year of trial for crossline over straightline calves.

This year will be the first breeding season of the Phase 2 study in which the maternal ability of the straightline heifers and crossline heifers will be investigated. This group of heifers will be divided into two herds with a crossline bull being bred to each.

Table 2. Summary of Straightbred and Contemporary Crossbred Heifers from Birth to 18 Months of Age - 1962-63

Breed groups	Number head	Birth weight	Weaning weight	Age at weaning	Gain birth to wean.	18-mo. weight on range[a]
		lb.	lb.	da.	lb.	lb.
Hereford	8	72	400	180	1.83	753
Angus	6	73	431	190	1.88	778
Charolais	9	93	539	197	2.27	953
H × A	8	68	449	201	1.90	807
A × H	8	70	422	197	1.78	788
Average	16	69	435	199	1.84	798
H × C	7	78	490	189	2.18	894
C × H	7	86	470	191	2.01	872
Average	14	82	480	190	2.10	883
A × C	10	78	472	189	2.09	864
C × A	10	83	469	192	2.01	895
Average	20	81	471	190	2.05	880
H × BS	4	83	521	193	2.27	896
A × BS	2	84	504	197	2.14	874
C x BS	3	110	567	186	2.45	942

[a]Unadjusted weights

Table 3. Record of Performance Summary of All Crossline and Straightline Bull Calves Fed - 1962-63 (196-day feeding period)

Line of sire	Line of dam herd[a]	Bull calves	Birth wt.	Wean. wt.	Age at wean.	Final weight off test	Gain on feed	Avg.da. Gain on test	Weight/ days of age
		no.	lb.	lb.	da.	lb.	lb.	lb.	lb.
1	Cl. 1	12	80	462	195	1038	584	2.98	2.60
4	Cl. 2	11	87	448	189	1044	607	3.10	2.65
6	Cl. 3	11	74	418	190	955	541	2.76	2.42
9	Cl. 4	13	73	408	191	928	535	2.73	2.34
10	Cl. 5	14	75	428	200	998	569	2.90	2.44

[a]Each breed group of cows consists of 30 head made up of 6 cows each of Lines 1, 4, 6, 9, and 10. Cows of each line are re-randomized into different breeding herds each year.

Table 4. Record of Performance Summary of All Crossline and Straightline Bull Calves Fed - 1963-64 (196-day feeding period)

Line of sire	Line of dam herd[a]	Bull calves	Birth wt.	Wean. wt.	Age at wean.	Final weight off test	Gain on feed	Avg.da. gain on test	Weight/ days of age
		no.	lb.	lb.	da.	lb.	lb.	lb.	lb.
1	Cl. 1	12	82	423	183	951	537	2.74	2.45
4	Cl. 2	9	80	433	194	1014	587	2.99	2.54
6	Cl. 3	11	77	421	194	943	526	2.68	2.37
9	Cl. 4	15	74	407	181	902	498	2.54	2.34
10	Cl. 5	10	88	452	188	999	557	2.84	2.54

[a]Each breed group of cows consists of 30 head made up of 6 cows each of Lines 1, 4, 6, 9, and 10. Cows of each line are re-randomized into different breeding herds each year.

Table 5. Comparison of Average Birth and Weaning Weights and Preweaning Gains of Straightline and Crossline Hereford Calves

	Straightline	Crossline
Bulls:		
Number	12	45
Birth weight (lb.)	80.6	79.3
ADG birth to weaning (lb.)	1.74	1.88
Age at weaning (days)	190.1	186.5
Weaning weight (lb.)	410.4	429.0
Adj. 180-day weight (lb.)	393.6	415.7
Gain in feedlot (lb.)	517.3	540.7
ADG in feedlot (lb.)	2.64	2.76
Heifers:		
Number	12	47
Birth weight (lb.)	75.1	78.6
Weaning weight (lb.)	386.8	415.1
Age at weaning (days)	191.6	190.7
Gain birth to weaning (ADG)	1.63	1.76

Project AH dl-2 (Rev. 2.) Development of superior lines of beef cattle

During the 1963 season, all the male calves in the Carcass Herd were left as bulls. Following weaning, they were placed in a feedlot and group fed for 196 days. At the end of the feeding trial, an evaluation of rib-eye area and fat thickness was obtained by the use of ultrasonics. The following index was used this year to select the first and second choice yearling bulls to be used for replacements:

$$\text{Index} = \frac{\frac{\text{weight}}{\text{days age}}}{\sigma} - \frac{\text{fat thickness}}{\sigma}$$

The herd of carcass cows is composed of 60 cows divided into two groups of 30 cows each. The same bull is mated to the same group of cows two years in succession. One new bull was selected this year on basis of the index evaluation and will be used in the same herd the following year. The second bull is in reserve.

Those bulls remaining after selecting the first two on basis of index were slaughtered at Fremont, Nebraska, where detailed carcass data were obtained.

Project AH d1-41 A study of response to selection and genetic-environmental interaction in genetically similar groups of Hereford cattle at two locations

Thirteen head of Line 1 heifer calves were shipped to Brooksville, Florida in the fall of 1963 to complete the number of Line 1 females making up the foundation herd. The same number of females were retained at this station. The first calves from the Brooksville females shipped to this station were born in 1963. The bull calves from both the Miles City and Florida cows were individually fed for a period of 196 days.

This year after selecting two bulls for replacements in the Florida herd, the remaining 11 bulls were sold for slaughter. From the 17 Miles City bulls, four were kept as replacements, one kept for sale, and the remaining 12 were slaughtered. All the slaughter bulls, with the exception of two that were sold and slaughtered locally, were shipped to Fremont, Nebraska, where carcass data were collected.

VI. Application of Findings:

The crossbreeding study at this station involving Hereford, Angus, Charolais, and Brown Swiss cattle has resulted in a sizable advantage in growth to weaning, 12 months, and 18 months of age for some of the crossbred groups over the straightbreds. The crossbreds from the Charolais and Brown Swiss crosses have been the heaviest at weaning, at 12 months, and at 18 months of age. In 1963, most all the crossbred and straightbred steers were marketed at approximately 1000 to 1050 pounds of weight. Some straightbreds, however, failed to reach the 1000-pound weight by July 15 and were sold before reaching that weight. While the crossbred steers of the Charolais and Brown Swiss crosses reached the 1000-pound live weight at an earlier age, the lack of marbling in the carcass resulted in fewer of them reaching Choice grade compared to the straightbred Angus, Hereford, or the Angus-Hereford crosses.

The second phase of the crossbreeding project studying the maternal ability of straightbred versus the crossbred heifer is being initiated this year. This sutdy is planned to help answer some of the questions now being asked by the livestock people in regard to the potential of getting greater production from the use of crossbred females.

The crossline breeding study, which has provided evidence of superiority of some of the lines for general combining ability, will be of considerable assistance and provide guidance in the future for determining the subsequent use of the present inbred lines at the station as well as for the use of other inbred bulls in industry. Presently, numerous requests are received from the commercial people asking about the economic advantage that could be expected from the use of inbred sires in their commercial herds.

The results from the Phase 2 Crossline Study being initiated this year, in which the maternal ability of the various linecross heifers will be compared with the straightline heifers, should provide information that is needed now for a more accurate appraisal of our inbred line study.

While the calves resulting from the carcass study have shown a considerable amount of merit for commercial production, more detailed analysis of the carcass data collected will be needed before it can be determined if any progress has been made in developing a more desirable meat type animal during the first few years of this study.

VII. Work Planned for the Future:

The first phase of the crossbreeding and crossline breeding project will be completed with the 1965 calf crop; thereafter, the major emphasis will be directed toward evaluating the maternal traits of the crossbred versus the straightbred heifers, and that of the crossline versus the straightline heifers resulting from the Phase 1 Studies. Several of the inbred lines from the Phase 1 Crossline Study and possibly some of the straightbred cows from the Phase 1 Crossbreeding Study will be retained for future studies. The present carcass study will be continued and emphasis placed on producing a desirable meat type steer with the aid of somascope on replacement bulls. Additional slaughter data will be helpful in determining the carcass merit of all bulls remaining after the replacements are selected.

One new feed mixing plant will be installed this summer. The cost of the building and installation of the mixing machine was provided through funds made available from the Commodity Credit Corporation. This addition to the station will be a large saving in labor cost and increase the efficiency of the feedlot operations.

VIII. Publications:

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Brinks, J. S., R. T. Clark, N. M. Kieffer, and J. J. Urick. 1964. Predicting wholesale cuts of beef from linear measurements obtained by photogrammetry. J. Anim. Sci. 23(2):365-374.

Brinks, J. S., R. T. Clark, N. M. Kieffer, and J. J. Urick. 1964. Estimates of genetic, environmental, and phenotypic parameters in range Hereford females. J. Anim. Sci. 23(3):711-716.

Brinks, J. S., R. T. Clark, N. M. Kieffer, and J. J. Urick. 1964. Predicting producing ability in range Hereford cows. Amer. Soc. Anim. Sci. West. Sect. Proc. 15:II-1-5. (Abs. 9.) J. Anim. Sci. 23(2):593.

Kieffer, N. M. 1964. Some aspects of inbreeding and selection for beef cattle improvement. Montana Farmer Stockman.

Urick, J. J. 1964. Can we improve feed efficiency by selecting for rapid gain. Montana Farmer Stockman. March.

Urick, J. J. 1964. Highlights of beef breeding research at the U. S. Range Livestock Experiment Station. Phillips County Livestock Growers Meeting. Malta, Montana.

IX. PROJECT SUMMARY

U. S. Range Livestock Experiment Station

Cattle Inventory — June 1964

Purebred

Breed	Hereford					
Line	1	4	6	9	10	11
Bulls (12 mo. or over)	22	5	8	7	7	8
Cows (2 yr. or over)	137	35	31	44	42	58
Heifers, yearlings	32	3	0	5	4	17
Steers, yearlings	10	0	0	3	0	13
Bull calves	17	7	2	9	3	25
Heifer calves	7	3	7	2	5	16
Percentage used for breeding project	100	100	100	100	100	100

Breed	Hereford			Charolais	Brown Swiss	Angus
Line	12	14	Fla.			
Bulls (12 mo. or over)	10	12	17	11	0	2
Cows (2 yr. or over)	70	71	39	72	36	67
Heifers, yearlings	21	21	9	14	0	7
Steers, yearlings	10	11	0	5	0	8
Bull calves	19	21	13	16	0	9
Heifer calves	26	18	16	11	0	10
Percentage used for breeding project	100	100	100	100	100	100

Breed	Hereford					
Line	Pur.	GEI	4 × 1 1 × 4	6 × 1 1 × 6	9 × 1 1 × 9	10 × 1 1 × 10
Bulls (12 mo. or over)	4	16	3	3	6	8
Cows (2 yr. or over)	25	39	7	5	4	2
Heifers, yearlings	0	15	5	4	6	1
Steers, yearlings	0	0	0	0	0	0
Bull calves	0	39	8	4	5	4
Heifer calves	0	18	4	4	5	7
Percentage used for breeding project	100	100	100	100	100	100

Breed	Hereford					
Line	6 × 4 4 × 6	9 × 4 4 × 9	10 × 4 4 × 10	9 × 6 6 × 9	10 × 6 6 × 10	9 × 10 10 × 9
Bulls (12 mo. or over)	4	8	4	5	3	2
Cows (2 yr. or over)	5	2	3	5	5	7
Heifers, yearlings	8	2	5	3	6	6
Steers, yearlings	0	0	0	0	0	0
Bull calves	7	5	4	4	5	5
Heifer calves	4	7	8	5	5	6
Percentage used for breeding project	100	100	100	100	100	100
Estimated cash value	$299,050					

Cattle Inventory

Grade

Breed	Hereford	A × H H × A	C × H H × C	H × BS	A × C C × A	A × BS	C × BS
Bulls (12 mo. or over	35	4	5	1	4	2	2
Cows (2 yr. or over)	218	16	14	4	20	2	3
Heifers, yearling	57	18	13	3	21	3	5
Steer yearlings	35	5	10	7	8	4	2
Bull calves	68	19	13	5	11	2	6
Heifer calves	77	12	13	1	13	5	3
Percentage used for breeding project	100	100	100	100	100	100	100
Estimated Cash value				$115,675			

Young Animals on Feed

Purebred	Hereford		Charolais			
	Number individually fed	Number group fed	Number individually fed	Number group fed	Number individually fed	Number group fed
Bulls	30	95		4		
Steers			3			
Grade	**Hereford**		**Angus**		**Crossbred[a]**	
Bulls		23				
Steers	6		6		36	

[a]Composed of C × H, H × C, A × H, H × A, C × BS, H × BS, A × BS, C × A, A × C

Physical Facilities and Equipment Used

	Number	Actual cash value	Percentage used for breeding project
Land	55,941 acres	$ 812,500	92
Buildings, corrals, land improvements, fence, residences, etc.		2,500,000	92

Cow Production Data 1963 Calf Crop

	Hereford	Hereford	Hereford
Line	1	9	10A
Cows bred (to calve at 3 yr. and up)	77[a]	11[b]	6
Calves born			
Alive	54	8	3
Dead	2	1	0
Total	56	9	3
Calves weaned	50	8	3
Percent calf crop			
Birth	74.7	90.0	50.0
Weaning	66.7	80.0	50.0

	Bulls		Heifers		Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:												
Birth weight	25	81.0	31	78.0	6	67.5	3	72.7	1	80.0	2	78.5
Weaning age		176.1		186.2		191.6		194.0		192.0		185.5
Weaning weight	21	406.9	29	406.3	5	398.8	3	410.0	1	390.0	2	346.5
Adj. weaning wt. 180 days		414.1		395.4		379.2		385.7		370.6		338.6
Weaning score:												
Conformation	21	75.9	27	76.4	5	75.0	3	74.7	1	78.0	2	74.5

[a]One pregnant cow sold to market November 1962. One died during breeding. Percentage computed on basis of 75 cows remaining.
[b]Sold one cow MCA November 1962. Pregnancy percentage calculated on remaining 10 head.

Cow Production Data 1963 Calf Crop

	Hereford				Hereford				Hereford			
Line	11A				11B				12A			
Cows bred (to calve at 3 yr. and up)	23[a]				26[b]				28[c]			
Calves born												
Alive	18				17				19			
Dead	1				3				2			
Total	19				20				21			
Calves weaned	17				17				18			
Percent calf crop												
Birth	86.4				87.0				77.8			
Weaning	77.3				73.9				66.7			
	Bulls		Heifers		Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:												
Birth weight	9	80.1	10	79.3	10	82.1	10	72.7	9	88.0	12	80.7
Weaning age		200.6		191.3		195.8		189.6		177.4		187.7
Weaning weight	7	498.6	10	424.7	10	470.6	7	430.9	8	396.8	10	399.1
Adj. weaning wt. 180 days		455.7		404.3		439.2		413.1		401.3		386.1
Weaning score:												
Conformation	7	81.3	10	77.9	10	81.3	7	79.1	7	76.6	10	77.2

[a]One pregnant cow sold November 13, 1962. Percentages calculated on basis of 22 head.
[b]Sold three pregnant cows November 13, 1962. Percentages on basis of 23 cows remaining.
[c]Sold one pregnant cow. Percentages based on 27 remaining cows.

Cow Production Data — 1963 Calf Crop

	Hereford	Hereford	Hereford
Line	12B	14A	14B
Cows bred (to calve at 3 yr. and up)	27[a]	26	27[b]
Calves born			
Alive	20	19	22
Dead	1	1	0
Total	21	20	22
Calves weaned	20	19	22
Percent calf crop			
Birth	87.5	76.9	88.0
Weaning	83.3	73.1	88.0

	Bulls		Heifers		Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:												
Birth weight	11	94.6	10	84.1	8	77.9	12	74.1	13	84.2	9	78.6
Weaning age		175.8		189.6		187.3		197.0		188.8		191.7
Weaning weight	10	439.1	10	436.0	7	407.4	12	418.3	13	455.4	9	433.9
Adj. weaning wt.		447.3		418.2		394.6		388.6		438.1		412.2
Weaning score:												
Conformation	10	77.0	10	79.0	7	76.7	12	79.8	13	78.8	9	79.6

[a]Sold three pregnant cows. Percentages calculated on basis of 24 remaining cows.

[b]Sold two pregnant cows November 13, 1962. Percentages calculated on basis of remaining cows.

Cow Production Data 1963 Calf Crop

Line	Hereford Crossline 1				Hereford Crossline 2				Hereford Crossline 3			
Cows bred (to calve at 3 yr. and up)	30				31[a]				31[b]			
Calves born												
Alive	29				25				22			
Dead	0				0				2			
Total	29				25				24			
Calves weaned	27				25				22			
Percent calf crop												
Birth	96.7				86.2				80.0			
Weaning	90.0				86.2				73.3			
	Bulls		Heifers		Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:												
Birth weight	15	81.6	14	75.4	10	81.0	15	76.7	12	76.9	11	77.0
Weaning age		180.7		190.2		193.8		196.1		193.7		191.7
Weaning weight	14	418.1	13	407.2	10	435.9	15	408.3	11	420.6	11	411.0
Adj. weaning wt. 180 days		416.8		389.6		410.6		381.1		396.3		390.6
Weaning score:												
Conformation	14	77.6	13	78.0	9	78.7	14	78.4	11	79.3	9	78.7

[a]Sold one pregnant cow November 13, 1962, one cow destroyed for prolapse. Percentage calculated on 29 remaining head.
[b]One cow died August 28, 1962, no pregnancy status. Percentage calculated on 30 remaining cows.

Cow Production Data 1963 Calf Crop

Line	Hereford Crossline 4	Hereford Crossline 5
Cows bred (to calve at 3 yr. and up)	30[a]	29[c]
Calves born		
Alive	27[b]	21
Dead	0	7
Total	27	28[d]
Calves weaned	26	20
Percent calf crop		
Birth	93.1	103.7
Weaning	89.7	74.1

	Bulls[b] No.	Bulls[b] Av.	Heifers No.	Heifers Av.	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.
Average:								
Birth weight	15	74.1	12	76.3	13	87.3	14	81.9
Weaning age		180.7		188.9		189.3		184.3
Weaning weight	15	407.2	11	412.5	11	449.9	9	408.4
Adj. weaning wt. 180 days		405.9		396.7		432.1		400.8
Weaning score:								
Conformation	14	76.9	11	77.2	11	81.1	9	78.1

[a]Sold one pregnant cow November 13, 1962. Percentage calculated on remaining 29 cows.
[b]One set twins included with 15 head bulls.
[c]One cow died without pregnancy test, one pregnant cow died prior to calving. Percentage calculated on remaining 27 cows.
[d]Including one set twins. Birth weight on one male missing.

Cow Production Data

Line	Crossbred A						Crossbred B					
Cows bred (to calve at 3 yr. and up)	29						29					
Calves born												
Alive	24						19					
Dead	0						0					
Total	24						19					
Calves weaned	23						19					
Percent calf crop												
Birth	82.8						65.5					
Weaning	79.3						65.5					
	Bulls		Steers		Heifers		Bulls		Steers		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:												
Birth weight	2	91.5	10	96.2	12	87.4	4	95.5	4	79.0	11	77.9
Weaning age		164.5		180.4		186.3		179.8		169.3		173.5
Weaning weight	2	423.0	9	512.0	12	484.7	4	496.5	4	434.5	11	421.6
Adj. weaning wt. 180 days		454.2		511.1		471.3		496.9		457.0		434.5
Weaning score:												
Conformation	2	76.5	9	77.2	12	79.3	4	77.3	4	74.5	11	76.5

Cow Production Data

Line	Crossbred C						Crossbred D			
Cows bred (to calve at 3 yr. and up)	27						24			
Calves born										
Alive	26						22			
Dead	0						0			
Total	26						22			
Calves weaned	25						20			
Percent calf crop										
Birth	96.3						91.7			
Weaning	92.6						83.3			
	Bulls		Steers		Heifers		Steers		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:										
Birth weight	3	101.3	6	95.8	17	88.9	11	83.1	11	71.8
Weaning age		196.3		189.0		197.6		182.0		185.7
Weaning weight	3	556.0	5	490.4	17	517.5	9	468.4	11	426.2
Adj. weaning wt. 180 days		518.2		471.6		479.3		464.2		415.3
Weaning score:										
Conformation	3	77.3	5	77.0	16	78.3	9	78.6	11	78.0

Cow Production Data

Line	Crossbred E						Crossbred F					
Cows bred (to calve at 3 yr. and up)	24						23					
Calves born												
Alive	21[a]						17[a]					
Dead	1						3					
Total	22						20					
Calves weaned	20						17					
Percent calf crop												
Birth	91.7						87.0					
Weaning	83.3						73.9					
	Bulls		Steers		Heifers		Bulls		Steers		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:												
Birth weight	7	79.6	7	68.9	8	68.0	1	86.0	12	80.6	7	81.7
Weaning age		191.1		195.0		199.3		201.0		196.2		186.0
Weaning weight	7	490.6	6	473.3	7	432.0	1	522.0	10	486.0	6	453.7
Adj. weaning wt. 180 days		466.7		442.5		396.9		476.4		452.5		441.7
Weaning score:												
Conformation	7	77.7	6	79.0	7	79.0	1	80.0	10	79.3	6	78.8

[a]Including one set of twins

Cow Production Data

Line	Crossbred G	Crossbred B
Cows bred (to calve at 3 yr. and up)	23	22
Calves born		
Alive	17	20[a]
Dead	0	0
Total	17	20
Calves weaned	17	19
Percent calf crop		
Birth	73.9	90.9
Weaning	73.9	86.4

	Crossbred G Bulls No.	Av.	Steers No.	Av.	Heifers No.	Av.	Crossbred B Bulls No.	Av.	Steers No.	Av.	Heifers No.	Av.
Average:												
Birth weight	3	86.3	5	84.6	9	77.7	3	81.7	7	80.1	10	80.0
Weaning age		186.7		163.0		184.7		196.3		190.3		194.4
Weaning weight	3	470.7	5	462.8	9	442.0	3	447.3	7	502.0	9	448.4
Adj. weaning wt. 180 days		456.9		502.2		432.7		416.9		479.2		421.2
Weaning score:												
Conformation	3	77.7	5	76.2	9	78.8	3	75.7	7	79.1	9	76.4

[a]Including one set of twins

Cow Production Data

Line	Crossbred I						Herefords Florida[a]			
Cows bred (to calve at 3 yr. and up)	22						26			
Calves born										
Alive	22						24			
Dead	0						0			
Total	22						24			
Calves weaned	21						22			
Percent calf crop										
Birth	100.0						92.3			
Weaning	95.5						84.6			
	Bulls		Steers		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:										
Birth weight	1	87.0	12	82.7	9	75.6	14	74.7	10	70.6
Weaning age		199.0		191.3		185.8		200.2		205.2
Weaning weight	1	572.0	12	463.0	8	410.8	13	470.8	9	403.6
Adj. weaning wt. 180 days		525.7		440.5		400.3		430.8		362.6
Weaning score:										
Conformation	1	82.0	12	76.5	8	77.1		b		b

[a]Shipped to Miles City as pregnant cows
[b]Assigned to GEI study. Scoring was under a different system.

Cow Production Data

Line	Hereford GEI Herd A (Miles City Line 1's)				Hereford GEI Herd B (Miles City Line 1's)			
Cows bred (to calve at 3 yr. and up	20				19			
Calves born								
Alive	17				16			
Dead	2				1			
Total	19				17			
Calves weaned	17				16			
Percent calf crop								
Birth	95.0				89.5			
Weaning	85.0				84.2			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	13	84.9	6	76.8	8	80.0	9	78.1
Weaning age		196.0		177.3		178.4		190.8
Weaning weight	11	446.2	6	408.7	7	373.1	9	422.7
Adj. weaning wt. 180 days		416.8		413.8		375.7		403.2
Weaning score:								
Conformation		a		a		a		a

[a]Scoring under GEI system

Cow Production Data

Line	Hereford Carcass Herd No. 1				Hereford Carcass Herd No. 2			
Cows bred (to calve at 3 yr. and up)	28				29[a]			
Calves born								
Alive	24				23			
Dead	0				2			
Total	24				25			
Calves weaned	23				23			
Percent calf crop								
Birth	85.7				89.3			
Weaning	82.1				82.1			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	12	86.2	11	82.5	12	85.4	13	82.0
Weaning age		184.0		196.5		195.4		189.4
Weaning weight	12	422.0	11	427.8	11	503.5	12	460.2
Adj. weaning wt. 180 days		414.7		398.8		470.5		441.5
Weaning score:								
Conformation	12	75.3	11	76.5	11	79.4	12	78.3

[a] One cow died October 1, no pregnancy test. Conception calculated on remaining 28 head.

Cow Production Data

Line	Hereford T1				Hereford T2			
Cows bred (to calve at 3 yr. and up)	32[a]				28[b]			
Calves born								
Alive	26				21			
Dead	0				0			
Total	26				21			
Calves weaned	25				21			
Percent calf crop								
Birth	96.3				87.5			
Weaning	92.6				87.5			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	18	90.2	8	78.0	10	88.4	11	82.0
Weaning age		186.5		193.3		197.3		197.2
Weaning weight	17	454.6	8	410.5	10	492.6	11	458.5
Adj. weaning wt. 180 days		441.9		387.6		457.2		425.7
Weaning score:								
Conformation	13	79.2	7	77.6	9	78.6	7	74.4

[a]Five pregnant cows sold November 13, 1962. Percentage calculated on 27 remaining.
[b]Four pregnant cows sold November 13, 1962. Percentage calculated on 24 remaining.

Feedlot Performance June 1964

Breed	Hereford						Charolais
Line	1	9	10	11	12	14	
Sex	Bull	Bull	Bull	Bull	Bull	Bull	Bull
No. on test	11	2	1	4	8	8	4
Average:							
Age on test	184.6	192.0	192.0	201.0	181.9	194.9	175.0
Initial weight	452.2	468.0	385.0	533.0	474.0	490.5	544.0
Weaning score	77.7	78.0	78.0	82.0	78.9	80.3	77.0
Days on test	196	196	196	196	196	196	196
Gain - total	511.1	439.5	460.0	531.0	526.1	542.0	474.0
Av. daily gain	2.61	2.24	2.35	2.71	2.68	2.77	2.42
Efficiency of feed utilization	h	h	h	h	h	h	h
Final weight	963.3	907.5	845.0	1064.0	1000.1	1032.5	1018.0

Breed	Hereford								
Line	Cross-line 1[a]	Cross-line 2[b]	Cross-line 3[c]	Cross-line 4[d]	Cross-line 5[e]	Carcass 1[f]	Carcass 2[g]	GEI	Florida
Sex	Bull	Bull	Bull	Bull	Bull	Bull	Bull	Bull	Bull
No. on test	12	9	11	15	10	12	11	17	13
Average:									
Age on test	183.2	194.2	193.7	180,7	188.4	184.0	195.4	187.4	200.2
Initial weight	414.3	427.3	417.8	404.3	442.5	407.7	485.8	413.0	456.3
Weaning score	78.3	78.3	79.3	76.9	81.3	75.4	79.4	---	--
Days on test	196	196	196	196	196	196	196	196	196
Gain - total	536.8	586.3	525.5	498.1	556.7	529.3	510.5	457.4	436.1
Av. daily gain	2.74	2.99	2.68	2.54	2.84	2.70	2.60	2.33	2.22
Efficiency of feed utilization - #TDN/100# gain	h	h	h	h	h	h	h	23.26	22.07
Final weight	951.0	1013.7	943.3	902.4	999.2	936.9	996.4	870.4	892.4

[a] L1 bull bred to L1, L4, L6, L9, and L10 cows.
[b] L4 bull bred to L1, L4, L6, L9, and L10 cows.
[c] L6 bull bred to L1, L4, L6, L9, and L10 cows.
[d] L9 bull bred to L1, L4, L6, L9, and L10 cows.
[e] L10 bull bred to L1, L4, L6, L9, and L10 cows.
[f] Hereford grade bull bred to Hereford grade cows.
[g] L1 bull bred to grade Hereford cows.
[h] Group fed.

UNIVERSITY OF NEVADA

I. Station: Nevada Agricultural Experiment Station, Reno, Nevada

II. Project title:

Interactions between genotype and environment in selection for economically important traits in Hereford cattle (Project 304 W-1)

The effect of genetic-environmental interaction on selection responses (Project 390 W-1)

III. Personnel:

Experiment Station:
C. M. Bailey, J. E. Hunter, C. L. Probert, C. R. Torrell, and H. J. Weeth

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, Coordinator, and J. S. Brinks

IV and V. Nature and extent of work done this year and summary of progress and conclusions to date:

Project 304 W-1:

Project revision:

The project revision submitted this past year has been approved. The five lines which were established in 1955 will be retained for several years. Lines 1, 2, and 3 (Rate-of-Gain, Economy-of-Gain, Conformation) will be maintained on irrigated pastures at the Main Station Field Laboratory, Reno, Nevada. Lines 4 and 5 (Rate-of-Gain, Economy-of-Gain) will be kept under range conditions at the Knoll Creek Field Laboratory near Contact, Nevada.

Two sires will be used in each line. Repeat matings will be used for estimating genetic progress. According to present plans, Rate-of-Gain and Economy-of-Gain lines at each location will be combined in about 1967. Random groups of breeding stocks will be transferred between locations during the period 1975 to 1980.

Performance test:

Sixty-two bulls and 56 heifers were performance tested in individual pens during 1963-64. Within locations, the lines were not greatly different this year in terms of feed conversion or conformation. Calves in the Rate-of-Gain and Economy-of-Gain lines at Reno (Lines 1 and 2)

were about 40 pounds heavier at the end of the test than calves in the Conformation line (Line 3).

Carcass check:

Bulls tested at Reno during 1963-64, which were not kept for breeding, were slaughtered at the conclusion of the testing period. Warm carcass weight, carcass grade, loin-eye tracings, and carcass specific gravity were recorded (table 1).

Table 1. Means of Carcass Characteristics of Bulls Slaughtered at the End of the 140-day Postweaning Performance Test (1963-64)

Item	Line 1	Line 2	Line 3
No. of carcasses	7	12	9
Warm carcass weight, lb.	357	379	346
No. of U.S.Good carcasses	5	10	7
Area rib eye, sq.in.	9.5	10.5	8.9
Specific gravity of left side	1.075	1.076	1.078

When slaughtered at the end of a time-constant feeding period, bulls from the Rate-of-Gain and Economy-of-Gain lines produced larger carcasses with greater rib area than carcasses from bulls in the Conformation line. Differences in carcass grade and fatness were small.

Effect of stilbestrol on bull characteristics:

Bulls tested at the Knoll Creek Field Laboratory during 1962-63 which were not retained for breeding were shipped to Reno for further feeding. A random half of the bulls from each line (Lines 4 and 5) were

Table 2. Means of Performance and Carcass Traits of Cull Bulls

	Line 4		Line 5	
Item	Stilbestrol	Control	Stilbestrol	Control
No. of bulls	6	3	7	6
Initial weight, lb.	517	495	562	564
Average daily gain, lb.[a]	2.88	2.45	3.13	2.84
No. of U. S. Choice carcasses	3	2	5	1
Area rib eye, sq.in.	14.0	16.0	12.9	13.3
Specific gravity of left side	1.072	1.073	1.070	1.075
Thick cuts in left side, %	73.9	73.0	73.8	73.9
Rib shear, lb.[b]	15.3	13.2	12.4	15.4
Rib tenderness[c]	6.3	6.8	6.9	6.2
Rib flavor[c]	6.2	6.5	6.4	6.1
Rib cooking loss, %	17.3	15.1	17.1	18.8

[a]Bulls received 2 lb. concentrate per 100 lb. body weight plus alfalfa hay *ad libitum*

[b]Warner-Bratzler Shear

[c]Values assigned by panel (9=like extremely, 1=dislike extremely)

implanted with 60 mg. of diethylstilbestrol at the start of the fattening period. The bulls were slaughtered at 950 pounds. Performance and carcass traits are summarized in table 2.

Twenty bulls which were culled at the end of the 1963-64 test (Lines 4 and 5) are being used in a similar comparison this year.

Project 390 W-1:

Crosses among inbred lines of rats:

All possible crosses were made among several inbred lines of rats. Data on litter size and weights at different ages were obtained. Statistical analyses of these data are not complete.

In a second pilot study, line-breds and linecrosses of two inbred lines of rats were fed either a standard diet or a mixture of 65 percent standard diet: 35 percent cellulose during the postweaning growth period. Fat composition of the males is being estimated by physical separation and chemical analysis. Weights of the females at breeding age will be obtained.

Selection experiment:

Rats from four unrelated inbred lines of rats were used to produce a base population for the selection experiment. Six breeding groups were established. Each group consists of 12 litters of four-way crosses. Three groups are being maintained on a standard diet. The other three receive a mixture of 55 percent standard diet: 45 percent cellulose during the postweaning growth period. Progenies in two of the groups on each diet will be selected for rapid growth. The other groups will serve as controls.

VI. Application of findings:

Work currently underway has not progressed to a stage where definite statements concerning the application of findings can be made.

VII. Work planned for the future:

1. The cattle selection experiment will be continued in accordance with the revised project outline.

2. Bulls tested at both locations during 1964-65 which are not retained for breeding will be fattened at Reno. Carcass characteristics will be studied.

3. Digestion studies will be conducted at both locations using random samples of calves from the five lines.

4. All line data collected from 1955 through 1965 will be organized for analysis.

5. Performance and carcass data for cull bulls used in the stilbestrol study during 1963 and 1964 will be analyzed.

6. Data from the parental stocks, F_1, and four-way crosses used in the rat selection experiment will be summarized.

VIII. Publications:

Bailey, C. M., C. L. Probert, Julianne Chancerelle, V. R. Bohman, and J. E. Hunter. 1964. Characteristics of young bulls and steers. (Abs. 48.) J. Anim. Sci. 23(3):858.

IX. PROJECT SUMMARY

Nevada Agricultural Experiment Station

Cattle Inventory
Purebred June 1964

Breed	Hereford	Hereford	Hereford	Hereford	Hereford
Line	1	2	3	4	5
Station	MSFL	MSFL	MSFL	KCFL	KCFL
Bulls 12 mo. or over	6	6	6	6	6
Cows 2 yr. or over	32	32	32	32	32
Heifers, yearlings	7	6	6	5	5
Bull calves[a]	12	10	10	5	13
Heifer calves[a]	11	11	12	9	13
Percentage used for breeding project	100	100	100	100	100
Estimated cash value	14,700	14,300	14,400	13,400	14,600

[a]Calf inventory as of May 15, 1964. Some cows will calve after May 15.

Land, Physical Facilities, and Equipment Used

	Number	Actual cash value	Percent used for breeding project
Main Station Field Laboratory	1	$350,000	20
Knoll Creek Field Laboratory	1	100,000	60
Other laboratory facilities		100,000	30

Cow Production Data

Breed	Hereford				Hereford				Hereford			
Line	1				2				3			
Cows bred 1962 to calve 1963 at 3 yr. and up[a]	31				31				30			
Calves born												
Alive	25				27				26			
Dead	2				0				0			
Total	27				27				26			
Calves weaned 1963	23				27				23			
Percent calf crop 1963												
Birth[b]	81				87				87			
Weaning[c]	74				87				77			
	Bulls		Heifers		Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:												
Weaning age, days	10	219	13	216	15	230	12	225	12	213	11	218
Weaning weight, lb.	10	438	13	402	15	472	12	441	12	417	11	389

Breed	Hereford				Hereford			
Line	4				5			
Cows bred 1962 to calve 1963 at 3 yr. and up[a]	31				31			
Calves born 1963								
Alive	23				25			
Dead	1				2			
Total	24				27			
Calves weaned 1963	22[d]				24			
Percent calf crop 1963								
Birth[b]	74				81			
Weaning[c]	71				77			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Weaning age, days	11	229	10	226	14	228	10	223
Weaning weight, lb.	11	414	10	397	14	426	10	394

[a]Cows which died or were removed from the herd after the start of the breeding season for any reason are included in "Cows exposed to the bull."

[b] $\frac{\text{Calves born alive}}{\text{Cows exposed to bull}} \times 100$

[c] $\frac{\text{Calves weaned}}{\text{Cows exposed to bull}} \times 100$

[d]Includes one calf raised on a nurse cow (not tested)

Nevada Agricultural Experiment Station

Feedlot Performance 1963-64

Breed	Hereford									
Line	1		2		3		4		5	
Sex	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers
Number on test	10	13	15	12	12	11	11	10	14	10
Average:										
Age on test, days	240	237	252	246	234	239	251	248	250	245
Initial wt., lb.	460	406	486	440	434	391	439	407	439	401
Initial score:										
Conformation[a]	83	84	84	84	83	83	84	84	84	84
Days on test	140	140	140	140	140	140	140	140	140	140
Gain--total, lb.	244	192	236	168	228	168	160	131	156	129
Avg. daily gain, lb.	1.74	1.37	1.68	1.20	1.63	1.20	1.14	.94	1.11	.92
Efficiency of feed utilization:										
lb. gain/cwt. TDN	19.2	17.1	18.8	15.1	18.7	15.0	16.4	15.0	16.2	15.0
Final weight, lb.	704	598	722	608	662	559	599	538	595	530
Conformation[a]	83	84	84	84	84	83	84	84	84	84

[a]California Agricultural Extension Circular 451, 1956. Scores from 100 (outstanding) to 67 (cull).

NEW MEXICO STATE UNIVERSITY

I. Station: New Mexico Agricultural Experiment Station, University Park, New Mexico

II. Project title: Breeding beef cattle for Southwestern ranges

III. Personnel:

Experiment Station:
L. A. Holland, J. H. Knox, and E. E. Ray

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, Coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

Data on 78 steers slaughtered in 1960, 1961, and 1962 were analyzed to estimate heritabilities of and correlations between traits. The steers were by 12 sires on the College Ranch, moved to the feedlots at the University, and after an adjustment period were allotted by sire and weight to lots where they were fed different rations. Live measurements were made before slaughter and carcass data were obtained in the meats laboratory. The carcass trait of particular interest was "retail trimmed high priced cuts," which consisted of the pounds of retail meat (bone in) in the rib, loin, round, and rump of the right side of the carcass.

Means and standard deviations of traits are listed in table 1.

Heritability estimates were made using Henderson's Method 2 to obtain the variance components. The model included year-lot and sire effects and age-at-slaughter as a covariate. The heritability estimates are shown in table 2.

Twelve sires with a total progeny of 78 is admittedly a small sample from which to estimate heritabilities. The estimates are generally lower than previously reported estimates. The estimate of heritability of retail high-priced cuts was zero. Other estimates for this trait have not been published.

Because of the many negative sire components obtained in the analysis, genetic correlations were not computed.

Phenotypic correlations between live traits computed within year lots are listed in table 3. Phenotypic correlations between live and carcass traits are shown in tables 4 and 5. Slaughter weight and live

Table 1. Means and Standard Deviations

Traits	Mean	Standard deviations Total	Standard deviations Within year-lots
Live animal:			
Slaughter age, days	483.30	30.12	27.30
Slaughter weight, lb.	824.60	62.65	58.47
Avg. daily gain, Lb./day	2.11	.28	.19
Slaughter grade	17.30	.80	.78
Wither height, in.	43.10	1.14	1.06
Depth of chest, in.	23.60	.91	.83
Width of loin, in.	12.90	1.08	.74
Length of loin, in.	9.00	.82	.77
Length of rump, in.	18.80	1.04	.88
Circumference of chest, in.	68.00	2.96	2.56
Circumference of cannon bone, in.	7.80	.30	.26
Carcass:			
Chilled carcass weight, lb.	493.40	39.97	39.40
Chilled dressing percent	59.90	1.95	1.79
Conformation score	6.00	.70	.66
Carcass grade	17.10	.96	.94
Amt. of marbling score	2.90	1.00	.89
Rib eye area, sq. in.	10.35	1.14	1.08
Fat thickness over rib eye, in.	.41	.13	.11
Retail trimmed high-priced cuts, lb.	75.00	11.14	5.32

Table 2. Heritability Estimates

Live animal traits		Carcass traits	
Slaughter weight	.00	Chilled carcass weight	.00
Avg. daily gain on feed	.67	Chilled dressing weight	.02
Slaughter grade	.00	Conformation score	.00
Wither height	.00	Grade	.00
Depth of chest	.00	Amount of marbling score	.29
Width of loin	.09	Rib eye area	.00
Length of loin	.00	Fat thickness, 12th rib	.05
Length of rump	.04	Retail trimmed high-priced cuts	.00
Circumference of chest	.24		
Circumference of cannon bone	.53		

Table 3. Simple Correlations between Live Traits

	Slaughter weight	A.D.G. on feed	Slaughter grade	Wither height	Depth of chest	Width of loin	Length of loin	Length of rump	Circ. of chest	Circ. of cannon
Slaughter age	.28*	.13	.23	.04	.19	.06	.04	.18	.17	.47**
Slaughter weight		.43**	.62**	.67**	.67**	.39**	.50**	.26*	.81**	.51**
Average daily gain on feed			.21	.24*	.29*	.14	.16	.16	.31**	.21
Slaughter grade				.39**	.44**	.26*	.33**	.21	.55**	.36**
Wither height					.67**	.41**	.42**	.06	.64**	.19
Depth of chest						.54**	.39**	.27*	.72**	.32**
Width of loin							.15	.13	.44**	.22
Length of loin								.07	.54**	.20
Length of rump									.18	.08
Circumference of chest										.41**

*P>.05 = .237
**P>.01 = .309

Table 4. Simple Correlations between Live and Carcass Traits

	Chilled carcass weight	Chilled dressing percent	Carcass confor-mation	Carcass grade	Amount of marbling score	Rib eye area	Fat thick-ness over rib eye	Retail trimmed high-priced cuts
Slaughter age	.28*	.08	.03	.14	.05	.04	-.04	.27*
Slaughter weight	.93**	.08	.42**	.56**	.36**	.32**	.48**	.77**
Average daily gain on feed	.32**	-.17	-.17	.17	-.01	.05	.19	.21
Slaughter grade	.68**	.31**	.59**	.67**	.38**	.31**	.54**	.57**
Wither height	.65**	.09	.31**	.48**	.40**	.17	.37**	.59**
Depth of chest	.65**	.11	.41**	.44**	.29*	.17	.43**	.63**
Width of loin	.45**	.27*	.29*	.31**	.23	.08	.21	.46**
Length of loin	.46**	.02	.21	.28*	.13	.31**	.39**	.39**
Length of rump	.31**	.19	.08	.12	-.06	.03	.24*	.20
Circumference of chest	.78**	.13	.41**	.56**	.36**	.23	.43**	.62**
Circumference of cannon	.49**	.09	.20	.12	.01	.27*	.00	.41**

*P>.05 = .237
**P>.01 = .309

Table 5. Partial Correlations between Live and Carcass Traits--
Slaughter Weight Held Constant

	Chilled carcass weight	Chilled dressing percent	Carcass confor-mation	Carcass grade	Amount of marbling score	Rib eye area	Fat thick-ness over rib eye	Retail trimmed high-priced cuts
Slaughter age	.06	.06	-.09	-.02	-.05	-.06	-.21	.09
Average daily gain	-.24*	-.23	.00	-.10	-.19	-.10	.03	-.21
Slaughter grade	.36**	.33**	.33**	.49**	.22	.15	.35**	.20
Wither height	.08	.06	.06	.17	.23	-.07	.07	.16
Depth of chest	.10	.08	.21	.10	.07	-.07	.16	.25*
Width of loin	.26*	.26*	.16	.12	.10	-.05	.03	.27*
Length of loin	-.01	-.02	.01	.00	-.06	.18	.19	.01
Length of rump	.18	.18	-.03	-.04	-.17	-.06	.13	.00
Circumference of chest	.12	.12	.16	.21	.13	-.06	.07	.00
Circumference of cannon bone	.05	.06	.00	-.22	-.22	.13	-.33**	.03

*P>.05 = .237
**P>.01 = .309

animal measurements were highly related (table 3). With slaughter weight held constant the correlations between live animal traits and carcass traits were generally low (table 5).

Two animals with a ventricular septal defect were autopsied during the past year, making a total of eight animals that have been observed with the defect. Two animals with patent foramen ovale and one with a patent ductus arteriosus were autopsied.

A project revision was submitted to the technical committee.

Tabulation of data for response to selection study was begun.

VI. Application of findings:

Live animal measurements were not accurate indicators of carcass traits when evaluated by partial correlation coefficients with slaughter weight held constant.

VII. Work planned for the future:

1. Complete analysis of and published relationships between live and carcass traits

2. Analyze response to selection

VIII. Publications

Sciacca, Carl E. 1963. Heritabilities and correlations between traits in Hereford steers. M. S. Thesis. New Mexico State University. University Park.

Knox, J. H. 1964. Breeding cattle adapted to less favorable regions. The Cattleman L(12):30, 42-44.

IX. PROJECT SUMMARY

New Mexico Agricultural Experiment Station

Cattle Inventory June 1964

	Purebred Hereford	Purebred Hereford	Grade Hereford
Line	Old	Outcross	Grade
Station	Main	Main	Main
Bulls (12 mo. or over)	9	2	
Cows (2 yr. or over)	36	19	135
Heifers, yearlings	8	4	
Bull calves	13	3	
Steer calves			43
Heifer calves	16	10	38
Percentage used for breeding project	70	70	40
Estimated cash value	$33,800	$10,800	$35,580

Feedlot Performance

Completed test in calendar year 1962

	Hereford	Hereford
Line	Old	Outcross
Sex	Bull	Bull
Number on test	10	2
Average:		
Age on test (mo.)	10	10
Initial weight	734	753
Initial score		
Days on test	140	140
Gain:		
Total	345	300
Daily	2.46	2.14
Efficiency of feed utilization:		
TDN/100 lb. gain	444.7	513.5
Final weight	1079	1053

Cow Production Data

Born July 1, 1962 to June 30, 1963

	Hereford	Hereford
Line	Old	Outcross
Cows bred to calve as 2 yr. olds	12	1
Calves born from 2-yr.-olds		
Alive	7	1
Dead	3	0
Cows bred to calve at 3 yrs. and up	29	14
Calves born from 3 yr.-olds and up		
Alive	27	11
Dead	0	1
All calves born		
Alive	34	12
Dead	3	1
Total	37	13
Calves weaned	29	11
Percent calf crop*		
Birth	90.2	86.7
Weaning	70.7	73.3

	Bulls		Steers		Heifers		Bulls		Steers		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:												
Birth weight	11	82.3	7	67.0	16	83.1	1	75	4	77.2	8	70.5
Weaning age		240		240		240		240		240		240
Weight-240 days	8	562	7	467	14	484	1	648	4	476	6	444
Weaning score:												
Condition	8	10.9	7	7.4	14	9.4	1	14	4	8.3	6	7.8
Conformation	8	7.0	7	6.4	14	6.9	1	8	4	6.3	6	6.5

$$\text{*Birth} = \frac{\text{Number live + dead calves at birth}}{\text{Number cows exposed}} \times 100$$

$$\text{Weaning} = \frac{\text{Number calves weaned}}{\text{Number cows exposed}} \times 100$$

Cow Production Data

	Hereford			
Line	Grade			
Cows bred to calve at 3 yrs. and up	79			
Calves born				
Alive	67			
Dead	6			
Total	73			
Calves weaned	66			
Percent calf crop*				
Birth	92			
Weaning	84			
	Steers		Heifers	
	No.	Av.	No.	Av.
Average:				
Weaning weight	31	350	35	336
A Adjusted weaning wt.- 205 days	383		356	
Weaning score:				
Condition				
Conformation	29	7.3	31	7.0

$$\text{* Birth} = \frac{\text{Number live + dead calves at birth}}{\text{Number cows exposed}} \times 100$$

$$\text{Weaning} = \frac{\text{Number calves weaned}}{\text{Number of cows exposed}} \times 100$$

Land, Physical Facilities, and Equipment Used June 1964

	Number	Actual cash value	Percentage used for Breeding project
Range land	63,000 acres	$189,000	33
Farm land	52 acres	52,000	33
Feed lots		30,000	50
Barns	2 only	120,000	70
Meat laboratory	1 only	100,000	10
Pathology laboratory	1 only	40,000	15
Calculators	4 only	2,800	60
Office equipment		600	60

OREGON STATE UNIVERSITY

I. Station: Oregon Agricultural Experiment Station, Corvallis, Oregon

II. Project Title: Diallel crossing in beef cattle and its use in breed improvement

III. Personnel:

Agricultural Experiment Station and Department of Animal Science:
Ralph Bogart, Walter Kennick, and A. T. Ralston

Statistics:
L. D. Calvin

Food Science and Technology:
A. F. Anglemier, W. K. Johnston, Frank Hoornbeek, and Jerry Green

Squaw Butte Cooperative Range and Livestock Station:
W. A. Sawyer and Joe Wallace

East Oregon Branch Experiment Station:
James McArthur

Malheur Branch Experiment Station:
E. N. Hoffman

John Jacob Astor Branch Experiment Station:
H. B. Howell

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado:
R. T. Clark, Coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

Objectives:

1. Determine the genetic value of Hereford lines 1, 2, and 3 by making diallel matings to test for specific and general combining abilities, maternal effects, and sex linkage

2. Assess heterotic effects by measurement of performance traits, carcass evaluations, blood and tissue chemical determinations, and physiological methods

3. Continue the development of the Angus line

4. Develop new Hereford lines from lines or line crosses of Oregon State and/or the U. S. Range Livestock Experiment Station

Major results of the year:

Diallel matings of the three Hereford lines at the Central Station were made for the second season in June and July and the first crop of calves from the matings made a year ago have been weaned. There are 37 linecross and 13 inbred Hereford calves. At the date when the first calves were weaned, July 24, 1963, the growth difference between linecross and inbred calves was 0.17 lb. per day in favor of the linecross calves. On the date when all calves had been weaned, November 13, 1963, the difference in growth rate between linecross and inbred calves was 0.09 lb. per day in favor of the linecross calves.

Data are being analyzed on the records of the four lines of cattle at the Central Station from the time the lines were started until the diallel matings were made. The analyses include the determination of the selection differential, progress made from selection, and the effects of inbreeding of the calf and of the dam for suckling gains, feed-test gains, feed efficiency, and conformation score within each of the four lines.

Certain members of the W-1 Technical Committee prepared a concise review of research done on beef cattle breeding in the Western Region which has been published as a regional bulletin, Oregon Agricultural Experiment Station Technical Bulletin 73.

Records on dam and offspring performance collected at the Squaw Butte Experiment Station, Burns, Oregon, were used to compute regression coefficients of offspring performance on dams' performance under two levels of feeding of dams. All calves were fed on the high level of feeding. Regression coefficients of offspring on dam were generally much higher when dams established their records on the high level as compared to those on the low level of feeding. It appears that more progress would be made by testing and selecting animals in the environment under which the animals are expected to produce.

Data on 230 cow-calf records collected at the Squaw Butte Experiment Station, Burns, Oregon, were used to study the relationship between cow weights and calf performance from birth through 18 months of age.

Although the relationships were fairly low, correlations and regressions dealing with the relationship of cow weights with calf performance indicated that heavier cows tend to produce calves that gain faster and are heavier from birth through 18 months of age. Calves from larger cows also tended to gain faster in the feedlot, consume more feed, and convert feed into pounds of gain more efficiently. Correlations involving 5 1/2-year weights of cows with calf performance were slightly higher than those involving 18-month weights of cows.

Two hundred fifty-four Hereford cattle were used to study the relationships of performance during the suckling period, weaner performance under high and low levels of feeding, and yearling performance on summer range. Part of these animals were fed through the long yearling period of growth to approximately two years of age which allowed expansion of the study to include performance during this period. Suckling gains were closely associated with two-year-old weight, were not related to performance as weaner calves, and were negatively correlated with yearling gains when animals had received the higher level of feed as weaner calves. Feeding weaner calves at a higher level tended to strengthen the relationship of weaner and long yearling performance and tended to weaken the relationship of weaner performance on feed with yearling performance on range. Two-year-old weight was more closely associated with weaner performance when high level of feeding was used and with long yearling performance when animals had received low level feeding as weaner calves.

Growth rate expressed as $\frac{\Delta \text{ weight}}{\Delta \text{ age}}$, at each 100-pound increment from birth to 800 pounds; feed efficiency expressed as $\frac{\text{gain in weight}}{\text{feed eaten}}$, at 500, 600, 700, and 800 pounds body weight; blood nitrogenous constituents, and urine urea nitrogen and ammonia were studied. Growth rate increased to 400 pounds weight, after which it was practically constant. Gain per unit of feed decreased from 0.143 pound at 500 pounds weight to 0.100 pound at 800 pounds weight, even though growth rate did not change. Amino acid nitrogen and urea nitrogen levels of the blood and urea nitrogen of the urine increased as calves grew from 600 to 800 pounds. More rapidly growing animals converted the feed they ate into body weight gains more efficiently than less rapidly gaining ones even though they ate no more per unit of body weight. Growth rate and efficiency of feed conversion were negatively associated with amino acid nitrogen and urea nitrogen levels of the blood and urea nitrogen of the urine. It appears that the younger (smaller) animal is more efficient in withdrawing amino acids from the blood to develop muscular tissues resulting in lower blood and urine levels of amino acids and their metabolites, whereas the older (larger) animal is less efficient, deaminizes amino acids and excretes large quantities of urea. Rapidly growing animals resemble younger animals physiologically. The levels of enzyme activities between slowly and rapidly growing animals or between younger and older animals indicate that the animal's metabolism and performance may be related to levels of enzyme activity.

EKG recordings from day 1 to day 4,570 have been obtained from 42 Hereford cattle by means of electrocardiograms. These age samples per animal very from one to six recordings. Thirteen figures, one table, and one sketch have been presented to illustrate the findings. Cardiac vector orientations vary with age and often with line of breeding. A given line will often show EKG age-pattern vector orientation changes that are opposite to the changes of another line. These opposing changes mean that a definite age must be stated whenever line differences are described. In general, horizontally oriented cardiac electrical vectors of newborn calves change with age to the more vertical orientation of older cattle. Records obtained during days 4 to 7 of a calf's life often assume unusual configurations.

Electrocardiograms (EKG) were obtained from 7 newborn beef calves and from 5 of these calves when they had attained 800 pounds of body weight. Six leads were obtained in each of two planes to provide the hexaxial frames of references from which the x, y, and z coordinates for the P, QRS, and T cardiac electrical vector axes were estimated. The vector projections of the P, QRS, and T-wave axes for each calf were calculated for each of the two planes. After tabulation of cardiac vector information, three-dimensional models were constructed to provide a specific visual image of the tabulated data. In addition, a stereographic projection or Wolff Net was utilized. In the newborn calf, the QRS axis was directed cephalid while the T axis was directed caudally. At 800 pounds of body weight, the QRS axis was directed dorsally and the T-waves in the EKG recordings were usually discordant at birth and remained discordant when adult weights were reached. The P vector at birth pointed mainly caudally, somewhat downward and slightly to the left. At 800 pounds of body weight, it pointed similarly caudally, markedly downward, and slightly to the left.

A male Hereford was found to have a cardiac anomaly known as the Eisenmenger complex. The bull was bred to four half-sibs, parent crossed, and out crossed to two other lines of breeding, but the parent cross and a half-sib mating failed. Analysis of the electrocardiograms of the resulting offspring produced data similar to previously published, presumably normal material.

Six electrocardiograms have been taken of a beef cow exhibiting both the normal and the W-P-W syndrome. These electrocardiograms have been illustrated, the cardiac electrical axes calculated, the vector loops constructed, and the cardiac intervals graphed. The P-QRS (W-P-W) interval seldom equals the P-QRS (normal) interval. The QRS and T wave axes exhibit similar relationships to each other whether normal or W-P-W patterns are calculated even though the orientations are markedly different.

VI. Work planned for next year:

Continue the diallel mating plan for the three Hereford lines at the Central Station.

Gather physiological data on calves produced by the diallel mating. Amino acid and urea nitrogen and creatinine of the blood will be obtained on all calves at 500 and at 800 pounds body weight and on animals slaughtered at time of slaughter.

Feed test all bulls and heifers and then carry bulls resulting from the diallel mating to 1000 pounds, at which time carcass data will be obtained from all that are not needed for breeding purposes. Carcass data are to include yield of trimmed wholesale cuts, percent lean, bone, and fat of a selected cut, and evaluation by a state panel.

Continue the Angus line as a two-sire line.

Continue to gather data at the Eastern Oregon Station of calf producing ability of cows sired by bulls from the four Hereford lines. Summarize data for analyses as rapidly as data are available.

Breed all heifers produced by the diallel matings to the same inbred Angus bull as a means of obtaining calves to measure calf producing abilities of these heifers.

Publish results obtained on relationships between scores on live animals at weaning and preslaughter with performance data, as determined by studies on a commercial herd, the lines at the Central Station, and the cattle at the Union Station.

Analyze data on the Angus and the three Hereford lines at Corvallis to determine selection actually practiced, progress made, and heritability estimates of suckling gains, feed-test gains, and feed efficiency within each of the lines. Relate progress in the lines to genetic base used to start the lines, deleterious genetic material in the lines, and rate and amount of inbreeding in the lines.

VIII. Publications:

Bogart, Ralph, Franklin R. Ampy, Allen F. Anglemier, and W. K. Johnson, Jr. 1963. Some physiological studies on growth and feed efficiency of beef cattle. J. Anim. Sci. 22(4):993-1000.

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Van Arsdel, Wm. C., III, Ralph Bogart, I. R. Jones, and G. A. Richardson. 1963. Letter to the Editor. Am. Heart J. 66(2):284.

Van Arsdel, Wm. C., III. Hugo Krueger, and Ralph Bogart. 1963. Age changes in the EKG of beef cattle. Oreg. Agr. Expt. Sta. Tech. B. 70.

Van Arsdel, W. C., H. Krueger, and Ralph Bogart. 1963. Vector orientation of P, QRS, and T axes in beef cattle. Amer. J. Vet. Res. 24(102):956-963.

PROJECT SUMMARY

Cattle Inventory
Purebred

May 1964

Station	Central						
Breed	Hereford			Angus	Hereford		
Line	Lion-heart	Prince	David		Lion-heart x Prince	Lion-heart x David	Prince x David
Bulls 12 mo. or over	6	4	5	4	5	8	5
Cows 2 yr. or over	22	21	22	22			
Heifers, yearlings	2	3	2	5	6	4	4
Calves							
Bull	3	5	1	14	5	5	4
Heifer	2	1	2	6	7	4	2
Percent used for breeding project	100	100	100	100	100	100	100
Estimated cash value	13,000	11,000	10,000	14,000	2,300	2,100	1,500

Cow Production Data

Breed	Hereford				Hereford			
Line	Lionheart				Prince			
Cows bred to calve as 2 yr. olds	4				6			
Calves born from 2 yr. olds								
Alive	2				4			
Dead	0				1			
Cows bred to calve at 3 yr. and up	19				19			
Calves born from 3 yr. olds and up								
Alive	14				16			
Dead	0				1			
All calves born								
Alive	16				20			
Dead	0				2			
Total	16				22			
Calves weaned	16				20			
Percent calf crop[a]								
Birth	70				80			
Weaning	70				80			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	11	79	5	76	11	81	9	70
Weaning age		200		171		197		188
Weaning weight	11	426	5	379	11	410	9	374
Adj. weaning wt.-180-days		397		406		388		365
Weaning score:								
Condition	11	9.9	5	10.6	11	10.0	9	10.1
Conformation	11	10.9	5	11.2	11	10.9	9	10.6

[a]Percent calf crop - birth = $\frac{\text{Number of calves born alive}}{\text{Total number of cows bred}} \times 100$

- weaning = $\frac{\text{Number of calves weaned}}{\text{Number of cows bred}} \times 100$

Cow Production Data

Breed	Hereford				Angus			
Line	David							
Cows bred to calve as 2 yr. olds	6				2			
Calves born from 2 yr. olds								
Alive	2				2			
Dead	0				0			
Cows bred to calve at 3 yr. and up	18				20			
Calves born from 3 yr. olds and up								
Alive	12				15			
Dead	1				0			
All calves born								
Alive	14				17			
Dead	1				0			
Total	15				17			
Calves weaned	14				17			
Percent calf crop[a]								
Birth	58				77			
Weaning	58				77			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	7	75	7	72	4	69	13	63
Weaning age		212		189		191		211
Weaning weight	7	413	7	364	4	448	13	426
Adj. weaning wt.-180 days		366		356		426		374
Weaning score								
Condition	7	10.4	7	10.4	4	10.1	5	10.6
Conformation	7	10.8		10.9	3	11.8	5	11.4

[a]Percent calf crop - birth $\frac{\text{Number of calves born alive}}{\text{Total number of cows bred}} \times 100$

weaning $\frac{\text{Number of calves weaned}}{\text{Number of cows bred}} \times 100$

Feedlot Performance

Breed	Hereford						Angus	
Line	Lionheart	Lionheart	Prince	Prince	David	David		
Sex	Bull	Heifer	Bull	Heifer	Bull	Heifer	Bull	Heifer
Number on test	4	2	1	3	1	2	3	5
Average								
age on test	212	200	258	225	275	195	191	199
Initial weight	450	400	450	400	450	400	450	400
Initial score:								
Condition	9.7	10.6	10.0	9.4	10.0	10.3	10.1	13.3
Conformation	11.0	11.3	11.0	9.6	11.0	11.2	11.8	14.2
Days on test[a]	129	167	110	159a	Test	173	125	281[a]
Gain - total[a]	350	350	350	350	not	350	350	350
Average daily gain[a]	2.79	2.14	3.22	2.24[a]	com-	2.05	2.83	1.82
Efficiency of feed					pleted			
utilization -								
#TDN/Lb. gain	606	767	538	697[a]		747	584	--
Final weight	800a	750	800	750		750	800	750
Final score:[a]								
Condition	11.7	12.1	11.0	11.0[a]		11.6	11.7	12.0
Conformation	12.5	12.3	11.0	12.0[a]		12.1	11.9	12.4
[a]Based on number of animals off tests				1				3

Feedlot Performance

Breed	Hereford					
Line	Lionheart X Prince		Lionheart X David		Prince X David	
Sex	Bull	Heifer	Bull	Heifer	Bull	Heifer
Number on test	7	6	9	4	7	4
Average age on test	214	181	222	219	208	244
Initial weight	450	400	450	400	450	400
Initial score:						
Condition	10.1	10.7	10.0	10.6	10.3	10.1
Conformation	11.2	11.2	10.8	10.9	10.6	10.9
Days on test	126	173	114	114[a]	127	173[a]
Gain - total	350	350	350	350	350	350
Average daily gain[a]	2.84	2.16	3.08	2.49[a]	2.77	1.96[a]
Efficiency of feed utilization - # TDN/ lb. gain	598	733	552	645[a]	588	728[a]
Final weight	800	750	800	750	800	750
Final score:						
Condition	12.1	12.5	11.4	12.8[a]	11.8	12.3[a]
Conformation	12.5	12.4	11.7	12.7[a]	12.0	12.2[a]
[a]Based on number of animals off test				3		2

Young Animals on Feed
Purebred

	Hereford		Angus	
	Number individually fed	Number group fed	Number individually fed	Number group fed
Bulls	18		1	
Heifers	5		1	
Steers	0		0	

Land, Physical Facilities, and Equipment Used

	Number	Actual cash value	Percentage used for breeding project
Land	500 acres	$155,000	100
Sheds	5	6,000	100
Silo	2	8,000	100
Barn	1	20,000	50
Tractors	2	9,000	50
Trucks	2	5,000	50
Scales	4	3,000	50
Squeezes	3	2,400	50
Flat bed	1	400	50
Brushcutter	1	500	50
Mower	1	500	50
Manure spreader	1	750	75
Sprayer	1	100	60
Hand truck	2	100	100
Loading chute	3	150	50
Corrals and pens		3,000	50
Misc. (saddle horse, vet. etc.)		1,000	50

UTAH STATE UNIVERSITY

I. Station: Utah Agricultural Experiment Station, Logan

II. Project Title: The development of breeding techniques and selection criteria for improvement of economically important characteristics in Hereford and Shorthorn cattle

III. Personnel:

Experiment Station:
J. A. Bennett, A. Junior Nyman, and Gren Owens (deceased)

IV. Nature and extent of work done this year:

The development of two lines of Herefords and one line of Shorthorn cattle through a system of mild inbreeding accompanied by selection on the basis of performance was continued. A test herd of known dwarf carrier cows also was maintained and one young Hereford bull was mated to these carrier cows. This year for the first time some line crosses were made. The Colorado Brae Arden Line and the Havre Line II were crossed with the Line I Herefords at Panguitch. Two bulls in the Brae Arden Line and two bulls in the Havre Line and two bulls of the Utah Line I were used. The cows were stratified according to prior calf weaning weight records and level of inbreeding and then allotted in approximately equal numbers to each of these bulls. Approximately one third of the Shorthorn cows were crossed to a Hereford bull. On this test it will not be possible to compare the reciprocal crosses but it will be possible to compare straight-bred Shorthorns with crossbred Hereford-Shorthorn calves and with straight-bred Hereford calves of the Logan herd. It is planned to compare the calves on the basis of birth weight, gains to weaning, and feedlot gains, and as far as possible carcass qualities will be measured.

This year all the bulls that were put on test were hand fed so that additional individual feed efficiency records would be obtained. Gains were considerably lower than last year when many of the calves were self fed, which again tends to demonstrate that self feeding gives faster gains than hand feeding even though the same pelleted ration is used. Gains were considered satisfactory, however, with the average daily gains for Herefords being 2.54 and the average Shorthorn daily gains being 2.61. There was a spread of approximately 0.9 of a pound between the top gaining bull and the poorest gaining bull, which illustrates that there is still considerable variation among the cattle in the ability to gain.

Further attention was given to methods of determining the amount of fat in live cattle. A new ultrasonic device developed by the Branson

Equipment Company specifically for measuring soft tissue in animals was obtained and limited tests have been run. The machine has been compared with the probe technique reported in the annual report for last year and shows very good agreement. In addition, 14 steers were measured with the machine then slaughtered and the actual fat depth measured on the carcass. There was a correlation of 0.75 between the two measures. It is felt that with more experience and improved technique this correlation will become much higher. There are some animals that carry considerable fat that give extra echo readings on the machine which in a few cases was interpreted as being the measure of the depth of back fat. This evidently is brought about by a streak of tissue of different density, either lean tissue or a membrane, that is reflecting the sound wave back. With increased experience we should be able to recognize these shallow readings and obtain the true depth of fat reading. Correlation would have been much higher if this error had not been made. It is felt that this machine shows great promise for measuring thickness of outside fat in beef cattle. It is very fast and the technique is easily developed.

V. Summary of progress:

The development of lines of Hereford and Shorthorn cattle is moving along as planned and the line testing work has now been started. At this stage it appears that the use of mild inbreeding accompanied by selection has considerable promise for developing lines of cattle of very satisfactory performance.

The use of 16 dwarf carrier cows for testing a sire for the presence of the dwarf gene seems to be practical and useful for lowering the frequency of the dwarf gene in the cattle.

The probe technique has been demonstrated to be a satisfactory method for measuring thickness of outside fat in cattle with acceptable accuracy. It does require proper technique but is reasonably fast. The ultrasonic machine will probably be faster and shows promise of being equally accurate. These methods, however, fall short of being accurate ways of estimating the total fat in live animals. There still is need for simple technique that will accomplish this measurement.

VI. Application of findings:

Selection on the basis of performance seems to be effective in improving cattle under a system of mild inbreeding (at a rate approximately equal to the use of a three-sire program). Testing procedures that are practical for application to ranchers have been developed and publicized. Many ranchers in the state are now doing on-the-ranch testing and the program seems to be growing.

Various methods have been developed for estimating the amount of body fat in the live animal, but as yet these are not practical for field application for measuring total fat. Methods have been found for measuring accurately and rapidly on a practical basis the amount of outside fat in live cattle.

VII. Work planned for next year:

1. Continue to develop lines of Hereford and Shorthorn cattle

2. Compare the performance of calves from line crosses of the Herefords with calves produced within the lines, and also compare the crossbred calves from mating Hereford bulls with Shorthorn cows with straight-bred Herefords and Shorthorns

3. Continue to study growth in cattle

4. Continue to investigate methods of estimating body composition and genotype in live cattle

5. Assist the Extension Service in developing the performance testing program among cattlemen in the state

VIII. Publications:

None

PROJECT SUMMARY

Utah Agricultural Experiment Station

Cattle Inventory June 1964

Breed	Hereford	Hereford	Shorthorn
Line	I	II	I
Station	Panguitch	Logan	Logan
Bulls 12 mo. or over	18	5	7
Cows 2 yr. or over	58	27	34
Heifers, yearlings	18	15	11
Bull calves	26	21	14
Heifer calves	27	9	16
Percentage used for breeding project	90	90	90
Estimated cash value	25,000	15,000	18,000

Utah State Agricultural Experiment Station

Cow Production Data June 1964

Breed	Hereford				Shorthorn	
Line	I		II		I	
Station	Panguitch		Logan		Logan	
Cows bred to calve as 2-yr. olds	7		4		6	
Calves born from 2-yr. olds						
Alive	7		4		4	
Dead	0		0		2	
Cows bred to calve at 3 yrs. and up	39		11		28	
Calves born from 3-yr.-olds and up						
Alive	36		10		25	
Dead	3		1		3	
All calves born						
Alive	43		14		29	
Dead	3		1		5	
Total	46		15		34	
Calves weaned	43		14		29	
Percent calf crop[a]						
Birth	88.5		93.8		94.4	
Weaning	82.7		87.5		80.5	
	Bulls No. Av.	Heifers No. Av.	Bulls No. Av.	Heifers No. Av.	Bulls No. Av.	Heifers No. Av.
Average:						
Birth weight	26 82	20 78	12 70	19 67	17 68	16 64
Weaning age	212.2	219.9	218.3	217.5	209.2	227.8
Weaning weight	25 434	18 423	11 404	18 369	13 412	15 404
Adj. weaning wt.-180 days	451.3	439.9	392.1	399.3	409.8	413.5
Weaning score:						
Condition	25 1.98	18 2.18	11 2.57	18 2.53	13 2.79	15 2.23
Conformation	25 1.91	18 1.97	11 2.05	18 2.10	13 2.25	15 1.92

Feedlot Performance

Breed	Hereford	Hereford	Shorthorn
Line	I	II	I
Sex	Bull	Bull	Bull
Number on test	15	3	5
Average age on test	282.6	294.6	296.0
Initial weight	623.4	613.5	653.6
Initial score			
Condition	1.77	2.33	2.40
Conformation	1.73	2.00	1.94
Days on test	98	98	98
Average daily gain	2.57	2.35	2.61
Efficiency of feed utilization-Lbs.TDN/lbs.gain	489.7	494.9	541.1
Final weight	875.7	843.7	908.9

Young Animals on Feed

	Hereford Line I		Hereford Line II		Shorthorn Line I	
	Number individu-fed	Number group fed	Number individu-fed	Number group fed	Number individu-fed	Number group fed
Bulls	16	0	3	0	5	0
Heifers	0	18	0	15	0	11
Steers	0	9	0	7	0	5

Land, Physical Facilities, and Equipment Used

	Number	Actual cash value	Percentage used for breeding project
Land - Panguitch	155	31,000.00	90
Logan	330	80,000.00	80
Shed, yards	5	60,000.00	90
Metabolism building	1	60,000.00	5
Special equipment		3,000.00	100

WASHINGTON STATE UNIVERSITY

I. Washington Agricultural Experiment Station, Pullman

II. Project Title: Comparison of breeding systems for improvement of beef cattle

III. Personnel:

Experiment Station:
C. C. O'Mary, Project Leader, and Douglas D. Bennett

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado
R. T. Clark, Coordinator, and J. S. Brinks

IV. Nature and extent of work done this year:

Three groups of Angus cows (A, B, C) were bred to two Angus bulls in 1963. The control group was randomly divided between the two Angus bulls. This procedure will give an opportunity to evaluate the performance of the two bulls, to make comparisons of the productive levels of the groups, and to establish a base from which progress can be measured. The calves from the first breeding are now on the ground and the results of weaning weights, gains, etc., of the present calf crop (1964) will be reported in the next annual report. This year the three groups are being bred to three bulls.

Two rations for performance testing of beef cattle were compared; one consisted of a concentrate mixture not pelleted (C) and hay, and the other of pellets (P) and hay. The results fully demonstrated that performance is affected by the type of ration. The bulls on the (C) ration gained 2.52 lb. per day compared with 2.12 lb. for those on the (P) ration. Heifers gained 1.90 lb. and 1.63 lb. per day on the two rations, respectively. Stockmen, therefore, in selecting breeding stock should make selections within groups tested alike if gains in genetic superiority are to be expected. While the desire is to select the top gaining animals, the (C) ration may be detrimental to the breeding stock, especially the heifers since they appear to get too fat.

Some stockmen may find it easier to weight only one time rather than use a 150-day performance test period. Thus, correlations were obtained between performance in daily gain during a 150-day test and weights at 15 months of age. The results indicate a correlation of 0.91 in the (C) ration group and 0.73 in the (P) ration group. Both correlation coefficients were highly significant. Fifteen-month weights would appear to be quite useful in making selections if data on a 150-day performance test were not available. Additional data are needed to confirm the above results before final recommendations are made.

The relationship between quantitative traits and sale price in 2-year-old bulls, yearling bulls, and heifers was determined. Records on 53 head of purebred beef cattle were included in the study. Information on weaning weights, adjusted to 205 days of age, and average daily gain on test (150 days for 2-year-olds, 141 days for yearlings), was made available under each pedigree in a sale catalog. Information on pounds of feed required per 100 pounds of gain was given on all Angus and on Shorthorn bulls. Weight per day of age was shown for all 2-year-old bulls.

The animals were sold at public auction in the order of Angus, Hereford, and Shorthorns and within breeds by age and sex groups--2-year-old bulls, yearling bulls, and yearling heifers.

Correlations between quantitative traits and sale price were calculated within breed, age, and sex groups. The results are shown in Tables 1 and 2.

Table 1. Means of Certain Quantitative Traits in Three Beef Cattle Breeds

Breed, age, and sex	Number of animals	205-day average weaning weight	Average daily gain on test	Feed required per cwt. gain	Weight per day of age	Average prices paid
Angus:		pounds	pounds	pounds	pounds	
Bulls						
2-yr.olds	11	513	2.62	737	2.20	$677.27
yearling	8	500	2.12	749		377.50
Heifers						
yearling	9	411	1.61	801		341.11
Hereford:						
Bulls						
2-yr.old	7	492	2.61		2.11	491.43
Shorthorn:						
Bulls						
2-yr.olds	6	520	2.84	753	2.02	510.00
yearling	5	457	2.62	773		320.00
Heifers						
yearling	7	401	1.77			194.29

Table 2. Correlations between Quantitative Traits and Sale Price in Registered Beef Cattle

Breed, age, and sex	Number of animals	Measurements correlated with sale price: 205-day weaning weight	Average daily gain	Feed required per cwt. gain	Weight per day of age
		pounds	pounds	pounds	pounds
Angus:					
2-yr.-old bulls	11	0.61*	0.07	-.06	0.60*
Yearling bulls	8	.59	-.08	-.67*	
Yearling heifers	9	.04	.24	.28	
Hereford:					
2-yr.-old bulls	7	-.06	.19		.18
Shorthorn:					
2-yr.-old bulls	6	-.37	.51	-.49	.84*
Yearling bulls	5	.54	.36	-.51	
Yearling heifers	7	.58	.40		

* 5 percent level of significance

Records were obtained from the Carnation polled Hereford herd, Carnation, Washington. Factors studied on 370 records were age of calf, age of dam, birth weight, season of birth, sex of calf, sire and year of birth. Significant differences were found between sexes and sires.

V. Summary of progress and conclusions to date:

Cooperation between Carnation farms, Carnation, Washington and Washington State University in an analysis of data on the Carnation Polled Hereford herd has been a major item of progress. Conclusions to date are that the practice of applying the same correction factors to herds under different management systems is questionable and more work needs to be done on this. Breeders in buying cattle seem to be using weight per day of age, or size, as a guide more than gain on test or feed efficiency.

VI. Application of findings:

Weight at 15 months appears to be well correlated with gain on test; thus, cattlemen with limited facilities may be able to get one weight on each of their bulls, and it be of value in making comparisons within their own group of bulls.

VII. Work planned for the future:

The Angus calves will be tested 150 days for gain and efficiency. One half of the bulls in each group will be slaughtered at 13 months for carcass data.

Carnation Farms has made semen available from their Register of Merit Hereford sire for use in the WSU Hereford herd. Carcass data will be obtained on one half of the male progeny (as steers) of this bull and on one half of the male progeny (as steers) of the WSU herd sire.

VIII. Publications:

Ament, Donald L., and C. C. O'Mary. 1963. Albinism and related blood disorders in Herefords. Amer. Soc. Anim. Sci. West. Sect. Proc. 14:I. [(Abs. 1.) J. Anim. Sci. 22(3):815.]

O'Mary, C. C. 1963. Relationship of feed efficiency to size in beef cattle. Feed Age 13(7):28-31.

O'Mary, Clayton C. 1963. Changes in beef cattle performance traits 1890-1960. Amer. Soc. Anim. Sci. West. Sect. Proc. 14:VIII. [(Abs. 27.) J. Anim. Sci. 22(3):821.]

O'Mary, C. C. 1963. Breed heifers to calve at two years. Shorthorn World. November. p. 5.

O'Mary, C. C. 1963. Evaluation of beef cattle on the basis of daily gains. Wash. State U. Dept. Anim. Sci. Stockmen's Handb. 14.

O'Mary, C. C. 1963. The relationship between size and efficiency in beef cattle. Wash. State U. Dept. Anim. Sci. Stockmen's Handb. 14.

O'Mary, C. C., and H. Levinsky. 1964. Melanin studies on coat color of albino cattle. (Abs. 26.) J. Anim. Sci. 23(3):852.

Richter, John A. 1964. Principal factors affecting weaning weights in beef cattle. M. S. Thesis. Washington State University. Pullman.

Shah, S. K. 1964. The relationship between specific body weight gain at specific ages in beef cattle. M. S. Thesis. Washington State University. Pullman.

Shah, S. K., and C. C. O'Mary. 1964. Specific age-weight relationships in beef cattle. (Abs. 30.) J. Anim. Sci. 23(3):854.

PROJECT SUMMARY

Washington Agricultural Experiment Station

Cattle Inventory

Purebred June 1964

Breed	Angus
Line	Eileenmere
Station	Washington
Bulls 12 mo. or over	21
Cows 2 yr. or over	61
Heifers, yearlings	14
Bull calves	22
Heifer calves	22
Percentage used for breeding project	100
Estimated cash value	$52,341

Cow Production Data 1963 Calf Crop

Breed	Angus
Line	Eileenmere
Cows bred to calve at 3 yr. and up	49
Calves born	
Alive	44
Dead	4
Total	48
Calves weaned	44
Percent calf crop[a]	
Birth	98
Weaning	90

	Bulls No.	Bulls Av.	Heifers No.	Heifers Av.
Birth weight	21	69.7	21	65.1
Weaning age		203.5		203.7
Weaning weight		472.5		403.7
Adjusted weaning weight 180 days		420.6		358.9

[a]Percent calf crop = $\frac{\text{number of calves}}{\text{number of cows bred}} \times 100$

Two crossbred calves not included

Feedlot Performance 1963 Calves

Breed	Angus	
Line	Eileenmere	
Sex	Female	Male
Number on test	21	18
Average:		
Age on test	218	218
Initial weight	504.6	439.8
Days on test	141	141
Total gain	309.2	236.0
Daily gain	1.67	2.19
Efficiency of feed utilization		
Lb. feed/100 lb. gain	625	584
Final weight	813.8	675.8

All animals were individually fed

UNIVERSITY OF WYOMING

I. Station: Wyoming Agricultural Experiment Station, Laramie and Gillette Substation, Gillette

II. Project Title: W.S. 655. Criteria for improving effectiveness of selection in beef cattle

III. Personnel:

Experiment Station:
G. E. Nelms, C. O. Schoonover, and R. A. Field, Animal Science Division; W. W. Ellis, Biochemistry Division; Leon Paules, Substation Division

U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado
R. T. Clark, Coordinator, and J. S. Brinks

IV. and V. Nature and extent of work done this year and summary of progress and conclusions to date:

The population at Gillette was closed to outside breeding in 1953. The results of the first 10 years have been summarized. The means and standard deviations are presented in table 1.

Table 1. Means and Standard Deviations

	Males		Females	
	Mean	S.D.	Mean	S.D.
Birth weight	75	7.4	68	7.1
180-day wt.	384	44	340	41
Gain on test	345	44	257	36
Final weight	742	78	604	71
Wt./day age	2.02	0.18	1.63	0.17

The average inbreeding coefficient in 1963 was 0.12 for the calves and 0.08 for their dams. The regression of the variables studied on inbreeding is shown in table 2.

Selection differentials were computed according to Dickerson et al., 1954. The average annual selection differentials in standard deviations from the sex-year mean are presented in table 3.

Table 2. Regression of Variables on Inbreeding

Variable	F_X	F_D
Birth weight	0.014	-.024
180-day weight	-1.377*	0.141
Gain on test	0.327	0.252
Final weight	-2.168*	-.018
Weight/day of age	-.00335	0.00147

*P<.05

Table 3. Average Annual Selection Differentials

Variable	Selection differentials
Birth weight	0.03[a]
180-day weight	0.05
Gain on test	0.09
Final weight	0.12
Weight/day of age	0.12

[a]Standard deviations from the sex-year mean

To measure the phenotypic responses in the traits studied, each trait regressed on years (table 4). Selection has been for unadjusted yearling weight (final weight). Therefore, changes in other traits are correlated responses. Sexes have been considered separately, since they were not handled the same.

Table 4. Regression of Traits on Years

Variable	Males	Females
Birth weight	0.61	0.55
180-day weight	5.3	3.3
Gain on test	3.0	0.2*
Final weight	10.9	5.2
Weight/day of age	0.03	0.02

*Not significant

Within sex year correlations are presented in table 5.

Carcass characteristics and consumer preferences for retail cuts from bulls and steers were studied. Bulls and steers from the same ranch were fed the same fattening ration in adjoining pens. Retail cuts were uniformly trimmed and displayed side by side in self-service counters of six retail stores at the same price per pound. Cuts used

Table 5. Phenotypic Correlations among Traits

	180-day weight	Gain on test	Final weight	Weight per day age
Birth weight	0.456	0.254	0.418	0.433
180-day weight		.245	.776	.755
Gain on test			.705	.760
Final weight				.952

included rump, rib, and chuck roasts, and rib, round, and loin steaks. Order of selection of the unidentified retail cuts were recorded. The only difference in visual preference was for chuck roasts. Bull chuck roasts were picked in preference to steer chuck roasts (175:107). After consumers had eaten the meat, they rated chuck roasts from bulls more desirable than chuck roasts from steers. Loin steaks from steers were rated higher than loin steaks from bulls. Differences in other cuts were small and nonsignificant. Eighty-nine percent of the replies indicated they would buy bull meat again.

VI. Application of findings:

It would appear that selection can be effective in small populations. Apparently, selection for body weight at one year of age is effective in increasing growth rate at younger stages.

Studies, comparing bull and steer meat indicate that bull meat is acceptable to the consumers when the source is unknown.

VII. Work planned for the future:

To be continued as outlined.

VIII. Publications:

Field, R. A., C. O. Schoonover, and G. E. Nelms. 1964. Carcass characteristics of bulls and steers. Amer. Soc. Anim. Sci. West. Sect. Proc. 15:XX. [(Abs. 25.) J. Anim. Sci. 23(2):597.]

Field, R. A., C. O. Schoonover, and G. E. Nelms. 1964. Consumer preferences for retail cuts from bulls and steers. Amer. Soc. Anim. Sci. West. Sect. Proc. 15:XXV. [(Abs. 26.) J. Anim. Sci. 23(2):597.]

Nelms, George E., and Paul C. Stratton. 1964. Phenotypic response to selection in a closed line of beef cattle. (Abs. 24.) J. Anim. Sci. 23(3):852.

PROJECT SUMMARY

Wyoming Agricultural Experiment Station

Cattle Inventory June 1, 1964

	Purebred				Grade
Breed	Hereford	Angus	Shorthorn	Hereford	Hereford
Station	Laramie	Laramie	Laramie	Gillette	Laramie
Bulls 12 mo.or over	5	6	4	6	2
Cows 2 yr.or over	38	34	22	35	19
Heifers, yearlings	9	10	9	8	4
Bull calves	16	18	10	15	6
Heifer calves	13	14	2	17	5
Percentage used for breeding project	100	100	100	100	100
Estimated cash value	13,125	12,900	6,900	12,800	4,550

Feedlot Performance

Breed	Hereford		Angus		Shorthorn		Hereford	
Line	Laramie		Laramie		Laramie		Gillette	
Sex	♂	♀	♂	♀	♂	♀	♂	♀
Number on test	14	14	18	10	10	9	15	11
Average:								
Age on test	226	220	225	213	215	227	222	222
Initial weight	359	366	373	342	406	375	434	383
Initial score								
Condition								
Conformation								
Days on test	168	168	168	168	168	168	168	168
Gain								
Total	424	245	383	251	416	248	448	272
Average daily gain	2.52	1.46	2.28	1.49	2.48	1.48		
Efficiency of feed utilization								
Final weight	783	611	756	593	822	623	882	655

Wyoming Agricultural Experiment Station

Cow Production Data — 1963 Calf Crop

Breed	Hereford				Shorthorn			
Line	Laramie				Laramie			
Cows bred to calve as 2-yr.olds	9				6			
Calves born from 2-yr.-olds								
Alive	8				3			
Dead	0				2			
Cows bred to calve at 3 yrs. and up	36				27			
Calves born from 3-yr.-olds and up								
Alive	33				20			
Dead	3				3			
All calves born								
Alive	40				23			
Dead	3				5			
Total	43				28			
Calves weaned	40				22			
Percent calf crop								
Birth[a]	95				85			
Weaning[b]	89				67			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	14	75.0	19	72.0	10	72.7	10	64.9
Weaning age		208		202		204		216
Weaning weight	14	344	19	353	10	399	10	379
Adj. weaning wt.-180 days		309		320		350		310
Weaning score:								
Condition								
Conformation	Not Scored							

[a]Percent calf crop = $\frac{\text{number born}}{\text{number bred to calve}} \times 100$

[b]Percent calf crop = $\frac{\text{number weaned}}{\text{number bred to calve}} \times 100$

Cow Production Data 1963 Calf Crop

Breed	Angus				Hereford			
Line	Laramie				Gillette			
Cows bred to calve as 2-yr.olds	8				8			
Calves born from 2-yr.-olds								
Alive	6				5			
Dead	1				3			
Cows bred to calve at 3 yrs and up	30				28			
Calves born from 3-yr.-olds and up								
Alive	28				22			
Dead	0				3			
All calves born								
Alive	34				27			
Dead	1				6			
Total	35				33			
Calves weaned	32				27			
Percent calf crop								
Birth[a]	92				92			
Weaning[b]	84				75			
	Bulls		Heifers		Bulls		Heifers	
	No.	Av.	No.	Av.	No.	Av.	No.	Av.
Average:								
Birth weight	20	59.4	11	54.5	15	77.5	11	72.5
Weaning age		214		202		201		201
Weaning weight	19	333	11	316	15	411	15	369
Adj. weaning wt.-180 days		309		298		385		366
Weaning score:								
Condition	Not Scored							
Conformation								

[a]Percent calf crop = $\frac{\text{number born}}{\text{number bred to calve}} \times 100$

[b]Percent calf crop = $\frac{\text{number weaned}}{\text{number bred to calve}} \times 100$

Young Animals on Feed

	Purebred			
	Hereford Number group fed	Angus Number group fed	Shorthorn Number group fed	Crossbred Number group fed
Bulls	30	18	10	11
Heifers	25	10	9	

Land, Physical Facilities, and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for Breeding Project
Portable corral	1	$1,875	100
GMC pickup	1	2,100	80
Headgate and corral gate	1 9	479	80
Platform scale	1	11	100
Mettler balance	1	778	30
Grain auger	1	252	50
Refrigerator	1	150	50
Semen unit	1	535	50

January 19

Chairman Pahnish opened the meeting at 8:00 A.M. and called on Dr. Cobb for comments on last year's S-10 meeting.

Cobb commented on some of the research work in progress at the Southern stations. He was especially impressed by the number of cattle on research projects in that area and by many of the facilities.

Pahnish called for annual reports from stations that had not reported the previous year.

Hawaii

Cobb discussed the progress of the Hawaiian work during the past year. Carcass information recently analyzed was discussed in detail and mimeographed information was distributed to committee members. Specific gravity of the carcass continued to be a good indicator of percent trimmed retail cuts.

The results of a least squares analysis on the effects of breeding group, year, sex, ranch, age of dam, age at weaning of calf, and several interactions on weaning weight, 12-month weight, 20-month weight, and corresponding grades were discussed and mimeographed information distributed to committee members.

Idaho

Christian discussed a recently completed study on adjusting weaning weights, listed in the Idaho annual report. Differences in accuracy were compared when incomplete data on age of dam or age of calf were available to the producer. Any method used that includes adjusting for age at weaning, sex, and age of dam will increase the accuracy of prediction.

Nevada

Bailey discussed the Nevada report with emphasis on the carcass traits of bulls on stilbestrol versus no stilbestrol. Implanted bulls gained more than controls.

Specific gravity of the carcass also is being used to estimate cutability at this station.

Work in progress on the selection study with rats was discussed. He stated that with the reduction of W-1 funds, the continuation of this project may be in danger.

New Mexico

Neumann reported on the progress of work at the New Mexico station during the year. Data on heritabilities and genetic correlations between performance and carcass traits were discussed. Small numbers and different feedlot treatments rendered the results difficult to interpret.

The heart defect observed in one of the lines is being studied in detail. Eight animals with a ventricular septal defect have been observed to date and two animals with patent foramen ovale and one with a patent ductus arteriosus were autopsied.

Oregon

Bogart discussed a recent analysis on response to selection on three Hereford and one Angus line from 1951 to 1962. Performance appeared to increase in the early stages followed by a leveling off period and a subsequent decline.

A study in progress on feed efficiency was discussed. Members suggested that k values or instantaneous feed efficiency values may offer promise in analyzing and interpreting data.

Preliminary data on the diallel crossing study were discussed by Bogart. Line differences in general combining ability are apparent to date.

Washington

O'Mary discussed the annual report of the Washington station. The facility housing the beef cattle burned during the year and he asked for suggestions on the type of facility to recommend that would enable studies of basic genetic-physiological importance to be performed. Bogart suggested a small facility where temperature, humidity, etc., could be controlled and basic physiological data obtained, with a larger conventional facility to house the majority of the cattle.

Wyoming

Nelms reported a selection study recently completed on the Gillette herd. Besides data listed in the annual report, the following figures were reported:

	Males		Females	
	F of calf	F of dam	F of calf	F of dam
Birth weight	-.05	-.06	0.11	-.05
180-day weight	-1.55	1.12	-1.41	-.16
Gain on test	.07	-.05	.27	.28
Final weight	-1.54	1.51	-1.22	-.32

A study completed on bull and steer performance and consumer acceptance was discussed. The data indicated that bull meat is acceptable to consumers when the source is unknown.

Project Revisions:

Chairman Pahnish called for stations to report on project revisions that had been circulated to the committee prior to the meeting.

Colorado

Stonaker discussed the revision of the Colorado project entitled "A Study of Selection, Inbreeding, and Crossing of Inbred Lines within the Hereford Breed." He also indicated concern over obtaining financial support for maintaining existing projects and initiating new projects in beef cattle breeding research.

Bogart moved that the Colorado project be accepted.

Bennett seconded the motion. Motion carried.

Hawaii

Reimer and Cobb discussed the new Hawaii project, "A Study of Heterosis from Crosses among Breeds of Beef Cattle."

Nelms suggested that equal numbers of Hereford and Angus cows be mated to Hereford, Angus,and Charolais sires.

Roubicek moved that the project be accepted.

Nelms seconded the motion. Motion carried.

Cobb also discussed additional W-1 work being carried out at the Hawaiian Ranch Company. One hundred thirty four heifers are being bred in six sire groups, four of which will be artificially inseminated with semen from bulls on the Arizona test, and one from an International Beef Breeders bull, and one group bred by natural service by a locally produced Record of Performance bull. The four bulls from the Arizona test are Clay's Supreme 33 (Bozeman), L4 Mischief 100 (Miles City), KC E311 (Nevada), and Royal 0006 (Colorado).

An additional 300 to 320 cows will be inseminated using semen from bulls in the Arizona project at another ranch. Preweaning and postweaning along with carcass information will be obtained. Up to ten sires will be represented depending on the number producing satisfactory semen.

New Mexico

Neumann presented the New Mexico revision, "Inheritance of Heart Defects and Evaluation of Factors Affecting Production and Anomalous Traits in Beef Cattle."

Bogart suggested that the New Mexico station consider purchasing electrocardiogram equipment and that no time limit be placed on the project.

Bogart moved the acceptance of this project.

O'Mary seconded the motion. Motion carried.

U. S. Range Livestock Experiment Station

Pahnish presented the outline for phase 3 of the crossbreeding study, "Breed Crossing for Increased Production in Beef Cattle." Discussion followed on the number of animals and the merits of including the synthetic variety.

Nelms moved the project be accepted.

Bogart seconded the motion. Motion carried.

Burris asked that the station personnel having project revisions accepted submit the appropriate form to Cooperative State Research Service.

Brinks indicated that project revisions are due during the next year for Montana, Utah, and Wyoming.

Wheeler asked about the present status of the Regional Research Project. Discussion followed on the objectives. Bogart suggested that the Chairman appoint a committee to review the Regional Project objectives and wording.

Cobb moved to refer this matter to the next Executive Committee.

Bogart seconded the motion. Motion carried.

Business Meeting

Chairman Pahnish asked Dr. Wheeler to comment on the use of trust funds.

Dr. Wheeler brought the matter of trust funds to the attention of the committee and asked for suggestions. Discussion followed on possible uses of these funds. Pahnish suggested the matter be tabled until later in the meeting.

Pahnish called for suggestions as to location for the next meeting.

Cobb moved that the next meeting be held in Fort Collins on July 9 and 10 preceeding the Western Section of American Society of Animal Science meetings.

Bogart seconded the motion.

Bailey discussed the possibility of meeting at Reno and noted that the national meetings of the American Society of Animal Science may be held there in 1967.

Nelms invited the group to Laramie.

The original motion to hold the meeting at Fort Collins on July 9 and 10 carried.

Stonaker discussed the Mendel Centennial to be held in Fort Collins in September and suggested this would be an appropriate time for the W-1 committee to meet.

Meeting recessed at 4:45 P.M.

January 20

Pahnish reopened the business meeting at 8:30 P.M. Wednesday.

The possible use of trust funds was discussed again.

Cobb moved that the Executive Committee take the responsibility for setting up a working committee to make suggestions for possible uses of trust funds at the next W-1 committee meeting.

Bogart seconded the motion. Motion carried.

Bogart moved that the committee continue to elect the Chairman in alphabetical order by states and elect W. C. Rollins Chairman for the coming year.

Christian seconded the motion. Motion carried.

Stonaker suggested that each station pay for the transportation by bus around the Island of Hawaii rather than the Hawaii station carrying the full expense.

Cobb stated that this may be hard to handle since the expense had already been approved by their director. Since complications were involved, the matter was dropped.

Pahnish asked for comments from Dr. Warwick, Beef Cattle Research Branch Chief.

Warwick discussed the forthcoming report from the Performance Records Committee which was made up of Extension, research, and industry personnel. He stated that he hoped all committee members would review this report and work with their state Extension people and other interested parties to help implement the procedures outlined in the report.

He discussed the loss of $60,000 in the Beef Cattle Research Branch budget. Support for the Nevada and California projects in the Western region will be discontinued effective July 1, 1965.

He discussed the task force meetings which were held when the Senate directed the Department of Agriculture to review livestock research and make recommendations as to needs and locations. This has been useful in giving the best inventory of beef cattle and livestock research to date. Recommendations as to needs and locations are not being made public at this time and were not discussed.

He discussed the possible move of the regional office from Denver to Fort Collins, and discussed reasons for the move. If suitable space is made available, the move probably will be made just prior to the end of the 1964-65 fiscal year.

Warwick discussed the multiple use reports. Presently the work of the Regional beef project is given in this report even though no W-1 money may be allotted to some states. He suggested that the reports be handled as in the past. Willson stated this is a good report as it keeps the staffs informed. Several members expressed favorable comments and stated that this report provided useful information. Bogart suggested that each committee member talk with his director and discuss the subject again at the next W-1 meeting.

Pahnish called on Dr. Burris, Cooperative State Research Service representative, for comments.

Burris discussed the regional genetic-environmental interaction study involving testing of bulls developed at various Western experiment stations and being tested at Arizona, Hawaii,and possibly other locations. He stated this approaches true regional research and has potential for real cooperative effort between states. Data analysis over several states yields valuable information.

He stated that we needed information on whether all states should be doing research or if the work should be concentrated at big central stations. He discussed the ideas of areas of outstanding research competence and putting money in the hands of outstanding individuals.

He cited the need for examples of research accomplishments and needs and invited committee members to send them to their office so they can be used.

He discussed the importation of semen and asked the committee if they might take action on using this potential source of semen.

He stated that he had no information on next year's budget. Stonaker commented on CCC monies through Cooperative State Research Service. Bogart stated that as much money in time and effort went into submitting projects as came out. Warwick stated that four projects were approved out of approximately 130 submitted, and none were approved in beef cattle genetics.

Pahnish called on Dr. Wheeler, Regional Administrative Adviser, for his comments.

Wheeler stated that there were two problems in financing projects: 1) The home base problem is to convince the local administration to support the projects, and 2) is to convince the Federal people to add support money to the W-1 project. The Directors are concerned about this. We may have to seek outside grant funds and make a strong effort with associations and producer groups to gain support at both the state and national level.

In 1965-66, we hope for possibilities of increased support. This is no time to diversify our efforts or not to identify ourselves with beef cattle as the research animal. Efforts must be made to sell the program to all possible channels.

Pahnish called on Dr. Brinks, Regional Investigations Leader, for comments.

Brinks distributed and discussed briefly the annual report of the regional project prepared for Cooperative State Research Service. Discussion followed on the subject of the present practice of each committeeman preparing two reports--one ending December 31 for Cooperative State Research Service and one ending June 30 for Agricultural Research Service. Emphasis was placed on the importance of having the reports current with respect to the time of the W-1 meetings.

He stated that the regional office hopes to fill the vacancy with an additional man to facilitate data analysis and manuscript production in the near future.

A visit to several of the stations is contemplated in the near future.

Brinks discussed the possibility of a regional bulletin on response to inbreeding and selection.

Stonaker suggested that inbreeding and selection be treated separately and that two bulletins be considered.

Brinks suggested the possibility of a series of bulletins on inbreeding, selection, and linecrossing and top-crossing results.

Rollins discussed the use of control populations.

Bogart moved that a committee be appointed by the Chairman consisting of all the contributors, with three persons responsible for writing, and that Brinks be one of the three members.

Willson seconded the motion. Motion carried.

Pahnish called for a report of the resolutions committee composed of Bogart (Chairman), Nelms, and Brinks.

Bogart presented the following resolutions:

University of Hawaii
Department of Animal Science

WHEREAS the members of the W-1 Technical Committee appreciate the excellent arrangements, program, and hospitality;

BE IT RESOLVED that we extend our thanks to Dr. Estel Cobb and through him to each and every staff member of the Department of Animal Science, University of Hawaii.

Bogart moved that the resolution be adopted.

Nelms seconded the motion. Motion carried.

Dr. R. T. Clark

WHEREAS Dr. R. T. Clark contributed greatly to the W-1 Beef Cattle Breeding Research from the initiation of the project until he resigned from the position of Coordinator;

BE IT RESOLVED that the appreciation of the members of the W-1 Technical Committee be made a part of the records of the 1965 meeting and that a copy of this resolution be conveyed to Mrs. Clark.

Bogart moved that the resolution be adopted.

Bennett seconded the motion. Motion carried.

Hawaiian Ranch Company

WHEREAS the Hawaiian Ranch Company, Inc. is contributing to the W-1 research program through cooperation with the University of Hawaii, and whereas the tour of the W-1 Committee on January 20, 1965 was possible through the efforts of Robert Hunter, Manager,

BE IT RESOLVED that the W-1 Technical Committee extend special thanks through a letter by the Secretary.

Bogart moved that the resolution be adopted.

Roubicek seconded the motion. Motion carried.

Hawaiian Sugar Cane Research Institute

WHEREAS the Hawaiian Sugar Cane Research Institute contributed greatly to the symposium at the 1965 W-1 Technical Committee meeting with the paper by Dr. John Warner,

BE IT RESOLVED that the W-1 Technical Committee extend special thanks through a letter by the Secretary.

Bogart moved that the resolution be adopted.

Nelms seconded the motion. Motion carried.

Pineapple Research Institute

WHEREAS the Pineapple Research Institute contributed greatly to the success of the W-1 Technical Committee meeting by Dr. J. B. Smith's presentation at the symposium and by the interesting tour,

BE IT RESOLVED that the W-1 Technical Committee extend special thanks through a letter by the Secretary.

Bogart moved that the resolution be adopted.

Nelms seconded the motion. Motion carried.

Stonaker suggested that the next meeting be at Fort Collins in September immediately preceeding the Mendel Centennial, but if not feasible,to keep the same dates as before.

Cobb moved to reopen the issue on when the next meeting would be held.

Stonaker seconded. Motion carried.

It was decided that the Executive Committee should look into the feasibility of the meeting in conjunction with the Mendel Centennial and to handle the decision by mail if considered feasible. Otherwise the dates would remain July 9 and 10, preceeding the Western Section meetings.

Christian moved the meeting be adjourned.

Bogart seconded. Meeting adjourned.

Pineapple Breeding in Hawaii

Jimmie B. Smith
Head, Plant Breeding Department
Pineapple Research Institute

The pineapple, Ananas comosus, traces its origins to South America where it was apparently greatly improved in the hands of the native Indians. Columbus was the first of many European explorers to discover the uniqueness of this fruit; certain of these expeditions carried plants back to the royal hot-houses of Europe, where the pineapple became known as the fruit of kings. During the 16th and 17th centuries, the Portugese and other explorers of the Pacific introduced the pineapple to places as far away as Malaya. Introduction into Hawaii seems to have come at a later date and from one or more secondary sources. However, it was in Hawaii that the fortunate combination of Yankee ingenuity, climate, and soil led to the first real development of pineapple agriculture, beginning in the early 1900's. The early formation of the Pineapple Research Institute as a cooperative effort of the pineapple companies in Hawaii has enabled this industry to become a 120 million dollar annual operation processing half of the world's solid pack and eighty percent of the juice.

Some forty years ago collections of other cultivars in the comosus species as well as other species and genera were assembled in Hawaii and hybridization was begun. Intercrossing of hybrids, maintained in the heterozygous condition by asexual propagation, then followed. Meantime, the technology both in field production and canning was based entirely upon the Smooth Cayenne clone, which still remains the sole production pineapple of Hawaii.

Faced with this long and successful history of production of a single type of pineapple, with an established market for the canned product, the breeder must achieve whatever gains available within this context. Improvement is possible in two ways: (1) Increased tonnage per acre and (2) Increased recovery percentages expressed as fancy slices per ton of raw fruit (analagous to dressing percentage in cattle). At the same time, the acceptability of the canned product must be demonstrated in side-by-side tests with Smooth Cayenne, which means that quality, in terms of sugar content, acidity, flavor, color, texture, etc., must remain high.

Given the limits of a processing system tied to a No. 2-1/2 can, major increases in tonnages per acre are possible only by increasing planting density. Much effort in the breeding program is now directed to development of suitable large fruited hybrids which, when crowded in the field, give fruits of similar size and as good or better recovery than Cayenne. Such hybrids now are available and they promise yield gains of 50 to 100 percent.

Improvement in recovery comes mainly from improvement in shape. As a result of earlier inter-specific and inter-varietal hybridizations, variability for shape ranges from nearly round to extreme cone shape. Selection here is for long cylinder of uniform diameter.

Apart from general selection for improved tonnage and recovery, other objectives include adaptation to new markets or production areas. Included here are categories for production in the tropics by Hawaii-based companies, winter production in Hawaii as opposed to standard summer harvest, production on land where specific disease problems exist, and production of pineapples especially for the growing fresh fruit market. In addition, the long-term needs of the industry suggest pineapple hybrids suitable for full mechanical harvest.

Each year some 150,000 seed are germinated and two years later about 75 percent of these are transferred to the field. First fruit are seen two additional years later and original selections made; further propagation is asexual from the original plant, with a maximum propagation ratio of 25:1, with conventional material, 3:1. Testing in field plots runs parallel to population increase. Fifteen years from selection, if a given hybrid survives all PRI and cooperative trials plus recovery and taste-test evaluations, it may be released to member companies for production. Another five to ten years are required to reach sizable production populations.

The general principle of breeding is recurrent selection starting with a very wide germ plasm base. Intermediate hybrids have been back-crossed to Cayenne, with newer ones selected from inter-crosses among them. Primarily, the scheme takes advantage of additive genetic variance, although no actual study of this has been made. Inbreeding is possible only with rare self-seedy plants since ordinary pineapple is self-incompatible; hence, production of hybrids as in corn, using inbred combinations to take advantage of dominance and epistasis, is impractical. Although initial selection is under relatively uniform conditions at one location, multiple site testing at later stages is basic to the program. Until now no major location-variety interactions have been established; this may only mean that the general plantation conditions are unusually uniform by virtue of soil fumigation and carefully controlled fertilization. Extension to production in the tropics may well make such interactions of greater significance.

Heritability Estimates and Genetic Correlations of Water Consumption in the Laboratory Rat

C. B. Roubicek

Animal Science Department
University of Arizona
Tucson

Since information is generally lacking on genotype × environmental effects on animal performance, a project was initiated with this as a primary objective. Various performance factors including reproduction, growth, and food and water consumption were measured. This report includes some of the initial results obtained with water consumption.

Experimental Material

Parental stock consisted of 21 different purchased lines of laboratory rats. For the first generation, two matings were made from each line. For successive generations, matings were made between lines with one sire mated to a single female. All matings were made in the colony room maintained at a constant 22°C. and the litters were kept there until weaning.

The litters were weaned at 21 days of age. Each litter was separated into males and females and the two sexes were then randomly allotted to two environmental conditions. Room number 1 was maintained at a constant 22°C. with 50 percent relative humidity. Room number 2 was maintained at a constant 35°C. with 35 percent relative humidity. Lights were turned on automatically from 7:00 A.M. to 7:00 P.M.

At weaning, each animal was weighed to the nearest gram, numbered, and placed in an individual cage. Purina lab chow was fed ad libitum on the cage floor. Water was provided by a 25 mm × 200 mm culture tube hung on the cage door. The culture tubes were fitted with a neoprene stopper and a bent stainless steel drinking tube. Depending upon the water consumption of the animal, one, two, or three of the drinking tubes were used for each cage so that adequate water was always available. Each morning the unconsumed water was measured back and fresh water provided. The animals were maintained under these conditions for a 13-week test period.

This report includes 1,639 progeny of 155 sires for five generations.

Computational Methods

In estimating heritabilities for the characteristics studied here, two models were used, following the report by Yamada (1962). In the first case it was assumed that the relationship of the character under different environments would be on a within-environment basis with the following model:

$$Y_{ijk} = \mu + \alpha_i + \beta_{ij} + e_{ijk}$$

$$i = 1,2: \quad j = 1,2, \ldots\ldots, r: \quad k = 1,2, \ldots\ldots, n_{ij}$$

where Y_{ijk} is the observed value of the kth individual in the jth group (litter) in the ith environment, with α_i the environment effect, β_{ij} the genetic effect in the ith environment, and e_{ijk} the individual variation within litters. The genetic effect and error are assumed random with expectation $\sigma^2_{b_i} + \sigma^2_{w_i}$, respectively. The analysis of variance with each environment was obtained on a within- and between-litter basis with unequal numbers in each litter. The analysis of variance for a given environment is as follows:

Source	d.f.	M.S.
Among litters	$r_i - 1$	$[\sum_j(\sum_k Y_{ijk})^2/n_{ij} - (\sum\sum_{jk} Y_{ijk})^2/\sum_j n_{ij}]r_i - 1$
Within litters	$\sum_j n_{ij} - r_i$	$[\sum\sum_{jk} Y^2_{ijk} - \sum_{jk}(\sum Y_{ijk})^2/n_{ij}]/\sum_j n_{ij} - r_i$

	E.M.S.
Among litters	$\sigma^2_w + n_o\sigma^2_{b_i}$
Within litters	$\sigma^2_{w_i}$

Here the calculations of the sums of squares and mean squares follow the standard procedures with the variance components estimated from the mean squares.

$$\sigma^2_w = \text{MS within litters}$$

$$\sigma^2_b = (\text{MS between litters} - \sigma^2_w)/n_o$$

where n_o is an average number of animals per litter, obtained:

$$n_o = [n_i - \sum_j n^2_{ij}/n_i]r_i - 1$$

An estimate of heritability can be obtained from:

$$2\hat{\sigma}^2_{b_i}/\hat{\sigma}^2_{b_i} + \hat{\sigma}^2_{wi}$$

since the matings were unique for each sire and dam, with each individual serving as a parent for a single litter.

The procedure of Falconer (1960) was used to determine the standard error of the heritability estimate when

$$SE_H = \sqrt{4\sigma^2_t}$$

and $\sigma^2_t = 2[1 + (n - 1)t]^2(1 - t)^2/n(n - 1)(N - 1)$

when
n = harmonic mean
N = number of litters (number of sires)
t = 1/2 of H

The second case was the model for estimating correlations between environments.

$$Y_{ijk} = \mu + \alpha_i + \beta_i + (\alpha\beta)_{ij} + e_{ijk}$$

where the added component $(\alpha\beta)_{ij}$ is the genetic by environment interaction. The genetic group effects and error effects were assumed to be random variables with zero expectation and variance σ^2_b and σ^2_w, respectively, and $(\alpha\beta)_{ij}$ with zero expectation and variance σ^2_I. The estimation of the interaction component was made on a litter basis, since each individual was subjected only to one environment, but each litter was represented by one or more individuals in both environments. The covariance term was calculated as follows:

$$M_o[\sum_j \overline{Y}_{ij}\ \overline{Y}_{i'j} - (\sum_j \overline{Y}_{ij})(\sum_j \overline{Y}_{ij'})]/r - 1$$

where $\overline{Y}_{ij}$ and $\overline{Y}_{i'j}$ represent the means for i and i' environments for the jth litter. The results give the mean square for the covariance between environments, weighted up to an individual basis. Then the mean square is an estimate of $n_o\ \sigma^2_{b_{ii'}}$ and $\sigma^2_{b_{ii'}}$ can be obtained from the covariance term.

Now if it is assumed that the estimates of litter means are unbiased and the correlation among individuals from a given litter is the same in both environments, then the genetic correlation under

two environments is given by

$$\hat{r}_g = \hat{\sigma}_{b_{ii}}/\hat{\sigma}_{b_i}\ \sigma_{b_{i'}}$$

Yamada gives a more generalized expression for mixed and random models, using a two-way analysis of variance (Robertson's formula) but this requires additional assumptions regarding equal within-group variances. An examination of the data used here did not warrant such an assumption and the more generalized analysis was not made.

The standard error of the genetic correlation (Falconer, 1960) is:

$$SEr_g = 1 - r^2 g/\sqrt{2}\ .\ \sqrt{\sigma_{H_x}\ \sigma_{H_y}/H_x\ H_y}$$

where H_x and H_y are the two heritabilities and σ_{H_x} and σ_{H_y} the respective standard errors.

Separate analyses were made for each sex and the calculations were performed in a single Fortran program giving the mean for each litter, the between- and within-group variances, and the heritability estimate for each environment, and the covariance and genetic correlation for the between-environment measurements. These results were tabulated separately for each period in the study for both weekly and cumulative periods to provide estimates of the time effect on the heritability measurements.

Table 1. Mean Values (ml.) of Water Consumption for Males and Females During Test Period at 22° and 35°C. Environmental Temperature

Week on test	22° Males	22° Females	35° Males	35° Females
1	129	123	178	171
2	191	181	336	329
3	237	216	369	379
4	268	238	389	396
5	301	256	396	398
6	332	277	398	402
7	343	285	391	402
8	350	300	398	406
9	360	308	406	410
10	358	316	406	417
11	362	320	410	417
12	363	327	409	410
13	363	333	413	413

Table 2. Heritability Estimates and Standard Errors for Weekly Water Consumption of Male and Female Rats at Environmental Temperatures of 22° and 35°C.

Week on test	Males 22°		Females 22°		Males 35°		Females 35°	
	H	SE	H	SE	H	SE	H	SE
1	1.03	0.12	0.95	0.12	1.34	0.08	1.21	0.10
2	1.20	.10	.89	.13	1.27	.09	1.21	.10
3	1.22	.10	.81	.13	1.36	.08	1.23	.10
4	1.21	.10	.59	.14	1.29	.08	1.23	.10
5	1.22	.10	.41	.15	1.25	.09	1.23	.10
6	1.09	.11	.40	.15	1.14	.10	1.24	.10
7	.85	.13	.55	.14	1.15	.10	1.13	.11
8	.66	.14	.51	.14	1.06	.11	1.04	.12
9	.75	.13	.47	.15	.98	.11	1.05	.12
10	.74	.13	.43	.15	1.01	.11	1.05	.12
11	.68	.14	.48	.15	1.07	.11	1.05	.12
12	.87	.13	.59	.14	1.08	.11	1.13	.11
13	.97	.12	.58	.14	1.08	.11	1.05	.12

Table 3. Heritability Estimates and Standard Errors for Cumulative Water Consumption of Male and Female Rats at Environmental Temperatures of 22° and 35°C.

Week on test	Males 22°		Females 22°		Males 35°		Females 35°	
	H	SE	H	SE	H	SE	H	SE
2	1.16	0.10	0.91	0.12	1.33	0.08	1.25	0.10
4	1.20	.10	.76	.13	1.36	.08	1.25	.10
6	1.21	.10	.58	.14	1.32	.08	1.25	.10
8	1.08	.12	.57	.14	1.27	.09	1.24	.10
10	.99	.12	.55	.14	1.21	.09	1.22	.10
13	.95	.12	.58	.14	1.18	.10	1.21	.10

Table 4. Genetic Correlations with Standard Errors for
Weekly Water Consumption of Rats
at Environmental Temperatures of 22° and 35°C. within Sex

Week on test	Males 22°	Males 35°	Females 22°	Females 35°
	rg	SE	rg	SE
1	0.90	0.01	0.82	0.03
2	.53	.08	.89	.02
3	.32	.07	.71	.05
4	.30	.07	.80	.04
5	.29	.06	.96	.01
6	.27	.09	1.09	.03
7	.10	.10	.73	.06
8	.27	.12	.91	.03
9	.22	.12	.96	.02
10	.42	.10	1.14	.05
11	.35	.15	1.12	.04
12	.36	.11	.95	.01
13	.20	.11	1.00	.01

Table 5. Genetic Correlations with Standard Errors for
Cumulative Water Consumption of Rats
at Environmental Temperatures of 22° and 35°C. within Sex

Week on test	Males 22°	Males 35°	Females 22°	Females 35°
	rg	SE	rg	SE
2	0.68	0.03	0.86	0.02
4	.50	.04	.87	.02
6	.42	.04	.98	.01
8	.35	.05	.93	.03
10	.34	.06	.97	.01
13	.33	.07	1.00	.01

Discussion

The heritability estimates and standard errors for weekly water consumption figures are shown in table 3. All heritability estimates are high except for the females at 22°. We must recognize that the heritability estimates obtained by full-sib correlation are likely to be near the upper limits of heritability. However, the consistency of the heritability estimate, especially at 35° C., together with the relatively low standard error, does indicate a major genetic influence on water consumption.

The genetic correlations of water consumption for each sex at the two environmental temperatures are shown in tables 4 and 5. The genetic correlations for cumulative water consumption (table 5) indicate that a genotype x environmental effect is present for males but not for the females.

This preliminary analysis would indicate that selection for increased water consumption could be effective under either environment for the females, whereas males would require selection under each environmental condition.

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Genetic-Environmental Interactions in Beef Cattle

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There is relatively little scientific evidence on existence of genetic-environmental interactions, and particularly on the ranges of environments and management systems through which they may be important to breeders.

Looking at the situation broadly, we are sure they exist--even though perhaps the evidence is not tied up neatly in scientific papers. Data from India provide an illustration of this.

Table from FAO Report by Phillips[a]

Breeding of cows	Number of records	Average milk kg.
1/8 imported	21	2200
1/4 "	175	2719
1/2 "	589	3171
5/8 "	204	3175
3/4 "	396	3029
7/8 "	86	2809

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The data are thus suggestive of a genetic-environmental interaction. Too much imported blood (in this case mostly Holstein) was less desirable than 1/2 to 5/8. Similar observations have been made with European breeds in many tropical countries. Perhaps this is best illustrated by a remark made by a South American, "In my country we'd rather eat inferior Zebu beef than to not eat superior beef from European breeds." The implication of a genetic-environmental interaction is clear. In that country, European breeds have difficulty surviving and, thus, a low or even zero production rate. We know that in temperate climates and with ample feed supplies, and in the absence of some disease situations, straight Zebus will not exceed the productivity of European breeds--indeed are likely to be inferior.

Even British breed proponents recognize the existence of this type of genetic-environmental interaction when they say that their breeds are suitable for production in the subtropic areas of the United States if ranchers will just get their feeding and management procedures in order.

An experiment was set up about ten years ago at the Range Cattle Station, Ona, Florida, to test the importance of this type of interaction. Three equivalent herds of cows were set up, each including pure Brahman and pure Shorthorns plus crosses with varying percentages of the two parental breeds. One herd is maintained on native range (low), one on a combination of native and improved pasture (medium management level), and one on improved pasture which is irrigated to produce as much clover as possible. To my knowledge, the growth data have not yet been comprehensively analyzed, but the last rough summary I saw showed that the Shorthorns were doing much better relative to the straight Brahmans at the higher nutritional levels. Crossbreds were exceeding both pure types at all management levels, but by a greater amount at the high level, thus possibly illustrating a greater heterotic effect for this trait under favorable conditions. This, in itself, is an indication of a type of genetic-environmental interaction. Data on percent calf crop weaned are not conclusive as yet.

In Texas and California studies (Cartwright, 1955; Rollins et al., 1964) it was found that Brahman and Brahman crossbred cattle outgained Herefords in the summer but not in cooler months, thus demonstrating an interaction.

The possibility of "heterosis-environmental" interactions can perhaps best be illustrated by calf crop. In several crossbreeding experiments now underway with British breeds in herds where calf crop raised averages 80 to 90 percent or thereabouts, crossbreeding has usually given a boost of 5 percent or more. Unless twinning occurred, and this is unlikely, an increase of this magnitude from crossing would be impossible under management situations in which calf crops of straightbreds are 95 percent or higher. Such situations do exist, although when calf crop is figured on a realistic basis I'm afraid they are rarer than most of us like to think.

The implications of the Zebu-European situation seem clear; namely, to use the types and/or combinations which best fit a given situation, taking into account both production efficiency and suitability of the product for supplying market demands. Compromise may be necessary.

I suppose the fact that virtually no long-time experiments of a sufficient magnitude to give conclusive results have been carried on to determine whether European breeds selected for productivity under adverse conditions can be improved without loss of product quality, and that few breeders have tried the same thing, can be taken as evidence of the impatience of the human race. There would appear to be a real area here for young men to initiate such trials and stick with them for a lifetime.

The question of genetic-environmental interaction is much less clear when we ask if genetic-environmental interactions exist within

breeds of cattle currently widely used in the nation and under environmental conditions that are fairly "normal." We might broadly define these as anything not subtropical. Intuitively, we might guess that the answer would depend upon the characters we take as endpoints and the nature of variation in management and environment.

Several years ago the American Hereford Association (Weber, 1951) sponsored work at three experiment stations (Ohio, Kansas, and Oklahoma) in which steers sired by small,medium, and large bulls were fed out under three management regimes; i.e., (1) full-fed in drylot immediately after weaning, (2) grazed a season and finished in drylot as long yearlings, and (3) fattened on grass as 2-year-olds.

All types attained what was then considered a satisfactory degree of finish under the immediate full-feeding regime, while the large types failed to do this under the deferred system. This would have to be interpreted as a "type-management" interaction.

The Colorado type study of the same period (Stonaker et al., 1952) likely would have resulted in a similar conclusion if all animals had been fed to a given final weight rather than to a given final degree of finish as was actually done. Had all been slaughtered at the weight at which the small-type animals had a satisfactory degree of finish, the large types would doubtless have been underfinished. Similarly, if slaughtered at weights at which large types were satisfactorily finished the small types would doubtless have had excessive finish.

Again, the conclusion to be drawn from this type of evidence seems fairly clear; namely, that breeders should select types of cattle suited for their production system and capable of finishing at desired weights under that production system.

We come now to the more subtle question of whether cattle of the same breed, of the same general apparent type, and with other similar characteristics insofar as we can see, differ in their abilities to respond to given environmental situations. If they do, then cattle should be bred and selected within fairly narrow ranges of the environments in which their descendants are expected to produce. If wider limits of adaptability are the general rule, then this need not be the case and breeders can have a broader range for selection and can thus widen the range of selection and perhaps made more rapid progress as a result.

Woodward and Clark (1950) reported on the progeny performance of 11 Hereford bulls progeny tested both at Miles City, Montana, and at Havre. In the latter test, I believe the postweaning feed tests were at Bozeman. Analyzed on an overall basis, ignoring years, there were significant sire-location interactions for most traits; i.e., birth weight, preweaning gain, postweaning gain, and feedlot efficiency.

However, not all bulls were used in the same years at each location, so part of the result may be due to year differences. In two sets of three bulls, each used at each location in the same years, changes in rank of progeny were less apparent, but even among them there were some striking changes in rank--these were not tested specifically for significance.

Montana workers (Urick et al., 1957) reported on the genetic relationships among gains during three successive postweaning growth periods; i.e., in drylot the first winter on a growing-fattening ration, grazing during the next summer, and a period in drylot on a fattening ration the second winter. Genetic correlations between gains in the two drylot periods and between the pasture period and second drylot period were very high. A genetic correlation of 0.45 between first winter and pasture gains was considered to be fairly high. It is, however, low enough to allow for some genetic-environmental interaction. The significance of this was not determined.

The Colorado station has progeny tested bulls from the various inbred lines developed in Colorado at a number of other locations including Mississippi, Oklahoma, Wyoming, and two locations in California as well as as their own station and two ranches in Colorado.

Dr. Stonaker kindly sent me a summary of the ranking of the lines in these various tests. While not yet statistically analyzed in detail, and probably not amenable to critical statistical analysis, it is Stonaker's opinion that, generally speaking, the lines tend to rank themselves in somewhat the same order in the various tests, both for preweaning and postweaning gains. There are, however, some differences in ranking at different locations with fairly adequate numbers. For example, the Brae Arden line has been highest in both preweaning and postweaning gain in progeny tests at the Colorado Station and at Dean Brown's ranch in California but was lowest of all lines tested at the Codding Ranch in Oklahoma. Thus, I doubt, and I hope Dr. Stonaker will speak up if he disagrees, that the data can be interpreted as indicating no interactions, but rather as being inconclusive on the subject.

A study has been underway at Iowa for several years in which sire progenies are split and fed out under three management regimes, which are an immediate full feeding and two deferred regimes. Cattle are slaughtered at a given degree of finish to date. Dr. Hazel tells me that 72 steers from 12 sires have been evaluated with no real evidence of genetic-environmental interactions for carcass traits measured. Analysis has not yet been made of production or palatability data.

A study is underway at the North Carolina station (Dillard et al., 1964) in which semen of the same Hereford bulls is used to inseminate cows in herds at three locations in the state; i.e., Mountains,

Piedmont, and on the Coast. To date, no positive evidence of important genetic-environmental interactions has been found.

Texas has reported results of trials in which sire progenies were split, with part fed for postweaning tests under two regimes. Lagos and Cartwright (1963) reports that in one experiment 56 Santa Gertrudis heifers by 10 sires were split and fed in drylot on "high concentrate" or on pasture with "concentrate supplement" (how much was not stated). Progenies ranked in the same order.

In a second experiment, 67 Hereford steers by 9 sires and 120 Brahman-Hereford steers by 15 sires were split and both fed in feedlot on either a 66 percent or 35 percent concentrate ration. No statistically significant sire × ration interactions were found. Among the Herefords, three pairs changed one place. Among the crossbreds, two groups changed rank 3 places, one group changed rank 2 places, and the remaining 12 groups either changed one place or had no change. Additive genetic variance was higher on the high concentrate ration. These workers concluded that either regime was satisfactory for testing gaining ability.

Work at Turrialba in Costa Rica (Maltos et al., 1961) with 10 sires and 110 progeny, with progenies split and tested on pssture and in drylot, showed significant sire × treatment interactions. In this work a pasture regime did not bring out genetid differences.

Arkansas (Brown and Gacula, 1962) has studied possible sire-management interactions in data in which the bulls from 42 progeny groups (408 head) were bard fed to gain over two pounds daily while their half sisters (402 head) were fed in either drylot or on pasture for gains of less than one pound. No sire × environment interactions were found.

We reported (Warwick et al., 1964) last year on some Beltsville work with identical twins which has a bearing on the question. Twenty-five pairs of monozygotic heifer twins of British beef breeds were used in a design in which part were fed a 75 percent concentrate ration to 800 pounds and part to the same weight on a ration entirely roughage except for needed protein supplement. Both members of some of the pairs were fed on the same ration while others were split. Significant or highly significant pair × ration interactions were observed for rate of gain, feed efficiency, and marbling score, while significance was approached for several other characters related to fat distribution and tenderness. In several cases the interaction variance exceeded the pair variance and even in cases where not significant was half or more as large.

These results cannot be interpreted as genetic-environmental interactions since the twins were accumulated at about five months of age and pretest environment (including prenatal) could have conditioned

pairs to perform proportiomately better or poorer on one or the other type of ration.

In summary, it would appear that we need more information on this question with beef cattle. Broadly speaking, genetic-environmental interactions do exist, but we are undertain as to their existence and importance in narrower ranges of both cattle and environment.

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Design and Analyses of Experiments on Genetic-Environmental Interactions

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The phenotypic expression of most quantitative characters we work with depends on a sequence of environments. In a broad sense, there are probably no completely independent genetic and environmental contributions to variation in animal performance. However, since differences in phenotypes among a series of genotypes can remain relatively constant, or can change over several differing environments, separate average genetic and environmental effects and their joint effect can be considered.

Historically, most population genetic studies have dealt with continuously varying characters in a particular environment. The additive contributions of genotypes and environment to the variation in phenotype have received the most emphasis. This primarily is because the joint effects are difficult or impossible to separate unless the experiment has been designed with this in mind. Wright (1939) recognized that the relationship between genotype and environment need not be additive and suggested that if important interactions exist a race would have to be bred for each ecological niche large enough to support one.

In recent years renewed interest has been shown in the field of genetic-environmental interactions. I especially like McBride's (1958) method of classification of the different types of genetic-environmental interactions. Although there is probably some overlap, this classification is useful in clarifying our thinking on this subject:

	Micro-Environmental	Macro-Environmental
Intrapopulation genotypes	A	B
Interpopulation genotypes	C	D

Type A deals with small environmental fluctuation of the intangible variety within a particular group. This type usually is ignored in analyses and is included as part of the error or within-group variance. Studies dealing with the reduction of within-group variation would be of this type. An example of this type of variation might be differences in aggressiveness among animals housed or fed together.

Type B interaction relates to the performance of similar genotypes under large differences in environment. The existence of this type of interaction may indicate the need to select in the environment in which the animal will produce. McBride (1958) differentiates between the static and dynamic forms of this interaction. Studies involving the static approach would be of the type being initiated in cooperation with the University of Arizona and other locations such as Hawaii--different lines of Hereford cattle being compared under several different environments. This study will yield information on the existence of this type of interaction.

The dynamic approach would be of the type outlined in the Miles City, Montana-Brooksville, Florida Genetic-Environmental Interaction project in which selection studies under the two environments are being carried out over a long period of time. This type of study yields information on the actual magnitude and effectiveness of this type of interaction or on effective heritabilities and correlated responses.

Type C interaction deals with the effects of environmental conditions at a particular location on large differences in genotypes. This may offer a practical explanation of heterosis, as some studies have shown that heterozygous animals are more buffered over a wider range of environments and are less subject to micro-environmental stresses than homozygous individuals. Certain aspects of crossbreeding studies would be of this type.

The existence of the Type D interaction--interpopulation, macro-environmental--may influence important decisions in animal breeding. If important, breeders would need to locate breeds or diverse strains that perform best when under their environment and location. This type of interaction is probably the most important type of genetic-environmental interaction the animal breeder is confronted with.

Since Falconer (1952) extended the idea of genetic correlation (Hazel 1943) to include the interaction of the same trait of the same genetic groups to two different environments, the idea has been widely accepted by population geneticists. The concept here is to consider the trait in two different environments as two different traits.

$$r_{g_1 g_2} = \frac{\sigma_{g_1 g_2}}{\sigma_{g_1} \sigma_{g_2}}$$

If the correlation is high, the same set of genes is primarily involved. If low, then the genes controlling the trait in the two environments differ to a great extent. The correlation may even be negative. The correlated response in environment two, when selection was practiced under environment one, is:

$$CR = ih_1h_2\ r_{g_1g_2}\ \sigma P_2$$

The appropriate product moment estimation of this genetic correlation can be obtained from the genetic components of variance and covariance for any pair of environments. The usual methods of analysis of variance, including the least squares approach we so often use, are suitable providing an appropriate model is used. Yamada (1962) gives an excellent description of how to obtain the necessary variance and covariance components from a within-environment analysis of variance and a between-environment covariance analysis. Besides indicating whether the interaction is significant, the genetic correlation method provides a value (correlation coefficient) that one can visualize and is more easily interpreted--at least by me.

Dickerson (1962) has has pointed out that when a larger number of environments are involved it may be more convenient to estimate the <u>average</u> degree of genetic correlations from the ordinary components of variance for genotypes ($\sigma^2{}_G$ across environments) and for the interaction ($\sigma^2{}_{GE}$) by the intraclass method as:

$$r_G' = \frac{\sigma^2{}_G}{\sigma^2{}_G + \sigma^2{}_{GE}}$$

Here, $\sigma^2{}_{GE}$ includes any real deviations of subclass means from their expectation based on the average absolute effects of the respective genotypes and environments. He further points out that if a proportional or multiplicative condition exists, a bias due to variance in genetic scale between environments will inflate this interaction component. He develops and presents the adjustment for this bias as the variance of the genetic scale, or $V(\sigma_{G_i})$. This correction can be made before computing the intraclass genetic correlations as:

$$r_G' = \frac{\sigma^2{}_G}{\sigma^2{}_G + \sigma^2{}_{GE'}}$$

where $$\sigma^2{}_{GE'} = \sigma^2{}_{GE} - V(\sigma_{G_i})$$

and $V(\sigma_{G_i})$ is the correction for variance in genetic scale between environments.

This correction would be especially needed in the analysis of threshold characters in different environments when they may be undetected in very favorable environments or completely overridden in highly unfavorable environments.

These two methods, then, 1) yield estimates of the specific degree of genetic correlation for any given pair of environments, and 2) the average degree of genetic correlation over a large number of environments. Both methods yield useful information. In fact, this seems somewhat analogous to general and specific combining ability obtained from data involving line and line-cross information.

In the analysis of data from the ten lines being tested at Arizona, Hawaii, and hopefully, other locations, both methods may be used to advantage. The first would yield information on degrees of specific adaptability and the second on the general adaptability of these lines.

The problem of whether the proper model should be random or mixed also exists. The genetic groups will probably be considered random in most studies we would be interested in. A case for either random or fixed environment could be made depending on the particular situation and the inferences to be drawn from the study. Yamada (1962) presents a discussion of this subject and discusses the bias that may be involved.

The analysis of data from the project now underway in the region would involve different years (4), locations (4?), and lines (10).

Following is a possible model:

$$Y_{ijkl} = \mu + E_i + L_j + (EL)_{ij} + Y_k + (EY)_{ik} + (LY)_{jk} + (ELY)_{ijk} + e_{ijkl}$$

Source	d.f.	Corresponding component obtained from EMS
E (environment or locations)	3	E
L (lines or genetic groups)	9	L
E × L	27	EL
Y (years)	3	Y
E × Y	9	EY
L × Y	27	LY
E × L × Y	81	ELY
error	n_e	W

The EL, or Environment × Lines, component is of the most interest from the genetic-environmental standpoint. The EY component has no significance from the genetic-environmental standpoint. The LY component would actually be due to the sire/line effect plus any true line times year interaction if, in fact, it exists. The three-way interaction ELY would probably be due primarily to a sire times environment interaction and may be of importance from the genetic-

environmental standpoint, especially if the EL effect is important.

Any desired intraclass correlation can be derived from these components of variance. Of special interest is the L/L + EL, which is the estimate of average degree of genetic correlation between progeny by the same line under different environments (locations).

Besides assessing the importance of genetic-environmental interaction, this particular project is of great value in testing the line for general combining ability and should shed some light on the effectiveness of selection and inbreeding in developing these lines.

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